Implementing OSPF on Cisco IOS XR Software

Open Shortest Path First (OSPF) is an Interior Gateway Protocol (IGP) developed by the OSPF working group of the Internet Engineering Task Force (IETF). Designed expressly for IP networks, OSPF supports IP subnetting and tagging of externally derived routing information. OSPF also allows packet authentication and uses IP multicast when sending and receiving packets.

Implementing OSPF version 3 (OSPFv3) expands on OSPF Version 2, to provide support for IPv6 routing prefixes.

This module describes the concepts and tasks you need to implement both versions of OSPF on your Cisco IOS XR router. The term "OSPF" implies both versions of the routing protocol, unless otherwise noted.

Note For more information about OSPF on the Cisco IOS XR software and complete descriptions of the OSPF commands listed in this module, see the "Related Documents" section of this module. To locate documentation for other commands that might appear during execution of a configuration task, search online in the Cisco IOS XR software master command index.

Feature History for Implementing OSPF on Cisco IOS XR Software

Release	Modification
Release 2.0	This feature was introduced on the Cisco CRS-1.
Release 3.0	No modification.
Release 3.2	Support was added for the Cisco XR 12000 Series Router.
Release 3.3.0	The following tasks were added: • Configuring OSPFv3 Graceful Restart • Enabling Multicast-Intact for OSPFv2 • Configuring the Multi-VRF Capability for OSPF Routing • Associating Interfaces to a VRF • Configuring OSPF as a Provider Edge to Customer Edge (PE-CE) Protocol • Configuring LDP-IGP Synchronization • Creating Multiple OSPF Instances (OSPF Process and a VRF)

Contents

Prerequisites for Implementing OSPF on Cisco IOS XR Software

The following are prerequisites for implementing OSPF on Cisco IOS XR Software:

- You must be in a user group associated with a task group that includes the proper task IDs for OSPF commands. Task IDs for commands are listed in the Cisco IOS XR Task ID Reference Guide. For detailed information about user groups and task IDs, see the *Configuring AAA Services on Cisco IOS XR Software* module of the *Cisco IOS XR System Security Configuration Guide*.
- Configuration tasks for OSPFv3 assume that you are familiar with IPv6 addressing and basic configuration. See the *Implementing Network Stack IPv4 and IPv6 on Cisco IOS XR Software* module of the *Cisco IOS XR IP Addresses and Services Configuration Guide* for information on IPv6 routing and addressing.
- Before you enable OSPFv3 on an interface, you must perform the following tasks:
  - Complete the OSPF network strategy and planning for your IPv6 network. For example, you must decide whether multiple areas are required.
  - Enable IPv6 on the interface.
- Configuring authentication (IP Security) is an optional task. If you choose to configure authentication, you must first decide whether to configure plain text or Message Digest 5 (MD5) authentication, and whether the authentication applies to an entire area or specific interfaces.

Information About Implementing OSPF on Cisco IOS XR Software

To implement OSPF you need to understand the following concepts:

- OSPF Functional Overview, page RC-171
- Key Features Supported in the Cisco IOS XR OSPF Implementation, page RC-172
- Comparison of Cisco IOS XR OSPFv3 and OSPFv2, page RC-173
- Importing Addresses into OSPFv3, page RC-173
- OSPF Hierarchical CLI and CLI Inheritance, page RC-173
- OSPF Routing Components, page RC-174
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- Supported OSPF Network Types, page RC-177

OSPF Functional Overview

OSPF is a routing protocol for IP. It is a link-state protocol, as opposed to a distance-vector protocol. A link-state protocol makes its routing decisions based on the states of the links that connect source and destination machines. The state of the link is a description of that interface and its relationship to its neighboring networking devices. The interface information includes the IP address of the interface, network mask, type of network to which it is connected, routers connected to that network, and so on. This information is propagated in various types of link-state advertisements (LSAs).

A router stores the collection of received LSA data in a link-state database. This database includes LSA data for the links of the router. The contents of the database, when subjected to the Dijkstra algorithm, extract data to create an OSPF routing table. The difference between the database and the routing table is that the database contains a complete collection of raw data; the routing table contains a list of shortest paths to known destinations through specific router interface ports.

OSPF is the IGP of choice because it scales to large networks. It uses areas to partition the network into more manageable sizes and to introduce hierarchy in the network. A router is attached to one or more areas in a network. All of the networking devices in an area maintain the same complete database information about the link states in their area only. They do not know about all link states in the network. The agreement of the database information among the routers in the area is called convergence.

At the intradomain level, OSPF can import routes learned using Intermediate System-to-Intermediate System (IS-IS). OSPF routes can also be exported into IS-IS. At the interdomain level, OSPF can import routes learned using Border Gateway Protocol (BGP). OSPF routes can be exported into BGP.

Unlike Routing Information Protocol (RIP), OSPF does not provide periodic routing updates. On becoming neighbors, OSPF routers establish an adjacency by exchanging and synchronizing their databases. After that, only changed routing information is propagated. Every router in an area advertises the costs and states of its links, sending this information in an LSA. This state information is sent to all OSPF neighbors one hop away. All the OSPF neighbors, in turn, send the state information unchanged. This flooding process continues until all devices in the area have the same link-state database.

To determine the best route to a destination, the software sums all of the costs of the links in a route to a destination. After each router has received routing information from the other networking devices, it runs the shortest path first (SPF) algorithm to calculate the best path to each destination network in the database.

The networking devices running OSPF detect topological changes in the network, flood link-state updates to neighbors, and quickly converge on a new view of the topology. Each OSPF router in the network soon has the same topological view again. OSPF allows multiple equal-cost paths to the same destination. Since all link-state information is flooded and used in the SPF calculation, multiple equal cost paths can be computed and used for routing.

On broadcast and nonbroadcast multiaccess (NBMA) networks, the designated router (DR) or backup DR performs the LSA flooding. On point-to-point networks, flooding simply exits an interface directly to a neighbor.

OSPF runs directly on top of IP; it does not use TCP or User Datagram Protocol (UDP). OSPF performs its own error correction by means of checksums in its packet header and LSAs.

In OSPFv3, the fundamental concepts are the same as OSPF Version 2, except that support is added for the increased address size of IPv6. New LSA types are created to carry IPv6 addresses and prefixes, and the protocol runs on an individual link basis rather than on an individual IP-subnet basis.

OSPF typically requires coordination among many internal routers: Area Border Routers (ABRs), which are routers attached to multiple areas, and Autonomous System Border Routers (ASBRs) that export reroutes from other sources (for example, IS-IS, BGP, or static routes) into the OSPF topology. At a minimum, OSPF-based routers or access servers can be configured with all default parameter values, no authentication, and interfaces assigned to areas. If you intend to customize your environment, you must ensure coordinated configurations of all routers.

Key Features Supported in the Cisco IOS XR OSPF Implementation

The Cisco IOS XR implementation of OSPF conforms to the OSPF Version 2 and OSPF Version 3 specifications detailed in the Internet RFC 2328 and RFC 2740, respectively.

The following key features are supported in the Cisco IOS XR implementation:

- Hierarchy—CLI hierarchy is supported.
- Inheritance—CLI inheritance is supported.
- Stub areas—Definition of stub areas is supported.
- NSF—Nonstop forwarding is supported.
- SPF throttling—Shortest path first throttling feature is supported.
- LSA throttling—LSA throttling feature is supported.
- Fast convergence—SPF and LSA throttle timers are set, configuring fast convergence. The OSPF LSA throttling feature provides a dynamic mechanism to slow down LSA updates in OSPF during network instability. LSA throttling also allows faster OSPF convergence by providing LSA rate limiting in milliseconds.
- Route redistribution—Routes learned using any IP routing protocol can be redistributed into any other IP routing protocol.
- Authentication—Plain text and MD5 authentication among neighboring routers within an area is supported.
- Routing interface parameters—Configurable parameters supported include interface output cost, retransmission interval, interface transmit delay, router priority, router “dead” and hello intervals, and authentication key.
- Virtual links—Virtual links are supported.

- Not-so-stubby area (NSSA)—RFC 1587 is supported.
- OSPF over demand circuit—RFC 1793 is supported.

Comparison of Cisco IOS XR OSPFv3 and OSPFv2

Much of the OSPFv3 protocol is the same as in OSPFv2. OSPFv3 is described in RFC 2740.

The key differences between the Cisco IOS XR OSPFv3 and OSPFv2 protocols are as follows:

- OSPFv3 expands on OSPFv2 to provide support for IPv6 routing prefixes and the larger size of IPv6 addresses.
- When using an NBMA interface in OSPFv3, users must manually configure the router with the list of neighbors. Neighboring routers are identified by the link local address of the attached interface of the neighbor.
- Unlike in OSPFv2, multiple OSPFv3 processes can be run on a link.
- LSAs in OSPFv3 are expressed as "prefix and prefix length" instead of "address and mask."
- The router ID is a 32-bit number with no relationship to an IPv6 address.

Importing Addresses into OSPFv3

When importing into OSPFv3 the set of addresses configured on an OSPFv3 interface, users cannot select specific addresses to be imported. Either all addresses are imported or no addresses are imported.

OSPF Hierarchical CLI and CLI Inheritance

Cisco IOS XR software introduces new OSPF configuration fundamentals consisting of hierarchical CLI and CLI inheritance.

Hierarchical CLI is the grouping of related network component information at defined hierarchical levels such as at the router, area, and interface levels. Hierarchical CLI allows for easier configuration, maintenance, and troubleshooting of OSPF configurations. When configuration commands are displayed together in their hierarchical context, visual inspections are simplified. Hierarchical CLI is intrinsic for CLI inheritance to be supported.

With CLI inheritance support, you need not explicitly configure a parameter for an area or interface. In Cisco IOS XR, the parameters of interfaces in the same area can be exclusively configured with a single command, or parameter values can be inherited from a higher hierarchical level—such as from the area configuration level or the router ospf configuration levels.

For example, the hello interval value for an interface is determined by this precedence "IF" statement:

If the **hello interval** command is configured at the interface configuration level, then use the interface configured value, else

If the **hello interval** command is configured at the area configuration level, then use the area configured value, else

If the **hello interval** command is configured at the router ospf configuration level, then use the router ospf configured value, else

Use the default value of the command.

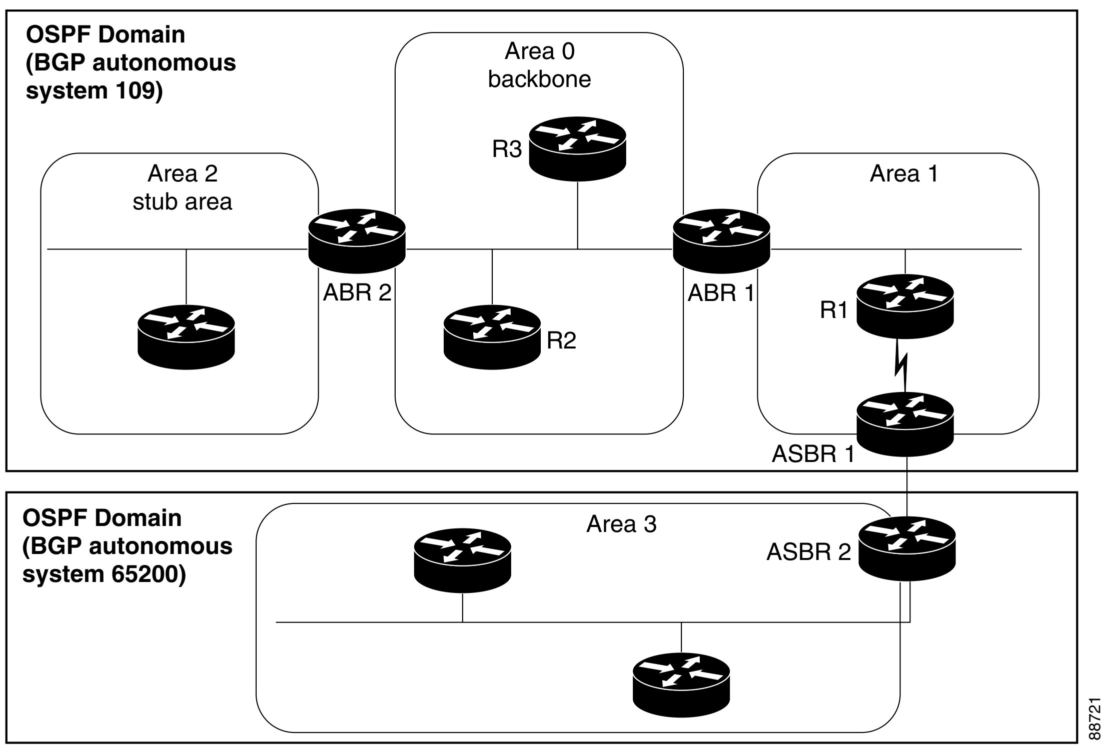
Tip Understanding hierarchical CLI and CLI inheritance saves you considerable configuration time. See the "Configuring Authentication at Different Hierarchical Levels for OSPF Version 2" section on page 194 to understand how to implement these fundamentals. In addition, Cisco IOS XR examples are provided in the "Configuration Examples for Implementing OSPF on Cisco IOS XR Software" section on page 236.

OSPF Routing Components

Before implementing OSPF, you must know what the routing components are and what purpose they serve. They consist of the autonomous system, area types, interior routers, ABRs, and ASBRs.

Figure 10 illustrates the routing components in an OSPF network topology.

Figure 10 OSPF Routing Components



Autonomous Systems

The autonomous system is a collection of networks, under the same administrative control, that share routing information with each other. An autonomous system is also referred to as a routing domain. Figure 10 shows two autonomous systems: A and B. An autonomous system can consist of one or more OSPF areas.

Areas

Areas allow the subdivision of an autonomous system into smaller, more manageable networks or sets of adjacent networks. As shown in Figure 10, autonomous system A consists of three areas: Area 0, Area 1, and Area 2.

OSPF hides the topology of an area from the rest of the autonomous system. The network topology for an area is visible only to routers inside that area. When OSPF routing is within an area, it is called *intra-area routing*. This routing limits the amount of link-state information flood into the network, reducing routing traffic. It also reduces the size of the topology information in each router, conserving processing and memory requirements in each router.

Also, the routers within an area cannot see the detailed network topology outside the area. Because of this restricted view of topological information, you can control traffic flow between areas and reduce routing traffic when the entire autonomous system is a single routing domain.

Backbone Area

A backbone area is responsible for distributing routing information between multiple areas of an autonomous system. OSPF routing occurring outside of an area is called *interarea routing*.

The backbone itself has all properties of an area. It consists of ABRs, routers, and networks only on the backbone. As shown in Figure 10, Area 0 is an OSPF backbone area. Any OSPF backbone area has a reserved area ID of 0.0.0.0.

Stub Area

A stub area is an area that does not accept or detailed network information external to the area. A stub area typically has only one router that interfaces the area to the rest of the autonomous system. The stub ABR advertises a single default route to external destinations into the stub area. Routers within a stub area use this route for destinations outside the area and the autonomous system. This relationship conserves LSA database space that would otherwise be used to store external LSAs flooded into the area. In Figure 10, Area 2 is a stub area that is reached only through ABR 2. Area 0 cannot be a stub area.

Not-so-Stubby Area

A Not-so-Stubby Area (NSSA) is similar to the stub area. NSSA does not flood Type 5 external LSAs from the core into the area, but can import autonomous system external routes in a limited fashion within the area.

NSSA allows importing of Type 7 autonomous system external routes within an NSSA area by redistribution. These Type 7 LSAs are translated into Type 5 LSAs by NSSA ABRs, which are flooded throughout the whole routing domain. Summarization and filtering are supported during the translation.

Use NSSA to simplify administration if you are a network administrator that must connect a central site using OSPF to a remote site that is using a different routing protocol.

Before NSSA, the connection between the corporate site border router and remote router could not be run as an OSPF stub area because routes for the remote site could not be redistributed into a stub area, and two routing protocols needed to be maintained. A simple protocol like RIP was usually run and handled the redistribution. With NSSA, you can extend OSPF to cover the remote connection by defining the area between the corporate router and remote router as an NSSA. Area 0 cannot be an NSSA.

Routers

The OSPF network is composed of ABRs, ASBRs, and interior routers.

Area Border Routers

An area border routers (ABR) is a router with multiple interfaces that connect directly to networks in two or more areas. An ABR runs a separate copy of the OSPF algorithm and maintains separate routing data for each area that is attached to, including the backbone area. ABRs also send configuration summaries for their attached areas to the backbone area, which then distributes this information to other OSPF areas in the autonomous system. In Figure 10, there are two ABRs. ABR 1 interfaces Area 1 to the backbone area. ABR 2 interfaces the backbone Area 0 to Area 2, a stub area.

Autonomous System Boundary Routers (ASBR)

An autonomous system boudary router (ASBR) provides connectivity from one autonomous system to another system. ASBRs exchange their autonomous system routing information with boundary routers in other autonomous systems. Every router inside an autonomous system knows how to reach the boundary routers for its autonomous system.

ASBRs can import external routing information from other protocols like BGP and redistribute them as AS-external (ASE) Type 5 LSAs to the OSPF network. If the Cisco IOS XR router is an ASBR, you can configure it to advertise VIP addresses for content as autonomous system external routes. In this way, ASBRs flood information about external networks to routers within the OSPF network.

ASBR routes can be advertised as a Type 1 or Type 2 ASE. The difference between Type 1 and Type 2 is how the cost is calculated. For a Type 2 ASE, only the external cost (metric) is considered when multiple paths to the same destination are compared. For a Type 1 ASE, the combination of the external cost and cost to reach the ASBR is used. Type 2 external cost is the default and is always more costly than an OSPF route and used only if no OSPF route exists.

Interior Routers

The interior routers (such as R1 in Figure 10) attached to one area (for example, all the interfaces reside in the same area).

OSPF Process and Router ID

An OSPF process is a logical routing entity running OSPF in a physical router. This logical routing entity should not be confused with the logical routing feature that allows a system administrator (known as the Cisco IOS XR Owner) to partition the physical box into separate routers.

A physical router can run multiple OSPF processes, although the only reason to do so would be to connect two or more OSPF domains. Each process has its own link-state database. The routes in the routing table are calculated from the link-state database. One OSPF process does not share routes with another OSPF process unless the routes are redistributed.

Each OSPF process is identified by a router ID. The router ID must be unique across the entire routing domain. OSPFv2 obtains a router ID from the following sources, in order of decreasing preference:

OSPF attempts to obtain a router ID in the following ways (in order of preference):

- The 32-bit numeric value specified by the OSPF **router-id** command in router configuration mode. (This value can be any 32-bit value. It is not restricted to the IPv4 addresses assigned to interfaces on this router, and need not be a routable IPv4 address.)

- The primary IPv4 address of the interface specified by the OSPF **router-id** command.
- The 32-bit numeric value specified by the **router-id** command in global configuration mode. (This value must be an IPv4 address assigned to an interface on this router.)
- By using the highest IPv4 address on a loopback interface in the system if the router is booted with saved loopback address configuration.
- The primary IPv4 address of an interface over which this OSPF process is running.

We recommend that the router ID be set by the **router-id** command in router configuration mode. Separate OSPF processes could share the same router ID, in which case they cannot reside in the same OSPF routing domain.

Supported OSPF Network Types

OSPF classifies different media into the following three types of networks by default:

- NBMA networks
- Point-to-point networks (POS)
- Broadcast networks (Gigabit Ethernet)

You can configure your Cisco IOS XR network as either a broadcast or an NBMA network. Using this feature, you can configure broadcast networks as NBMA networks when, for example, you have routers in your network that do not support multicast addressing.

Route Authentication Methods for OSPF Version 2

OSPF Version 2 supports two types of authentication: plain text authentication and MD5 authentication. By default, no authentication is enabled (referred to as null authentication in RFC 2178).

Plain Text Authentication

Plain text authentication (also known as Type 1 authentication) uses a password that travels on the physical medium and is easily visible to someone that does not have access permission and could use the password to infiltrate a network. Therefore, plain text authentication does not provide security. It might protect against a faulty implementation of OSPF or a misconfigured OSPF interface trying to send erroneous OSPF packets.

MD5 Authentication

MD5 authentication provides a means of security. No password travels on the physical medium. Instead, the router uses MD5 to produce a message digest of the OSPF packet plus the key, which is sent on the physical medium. Using MD5 authentication prevents a router from accepting unauthorized or deliberately malicious routing updates, which could compromise your network security by diverting your traffic.

Note MD5 authentication supports multiple keys, requiring that a key number be associated with a key.

Authentication Strategies

Authentication can be specified for an entire process or area, or on an interface or a virtual link. An interface or virtual link can be configured for only one type of authentication, not both. Authentication configured for an interface or virtual link overrides authentication configured for the area or process.

If you intend for all interfaces in an area to use the same type of authentication, you can configure fewer commands if you use the **authentication** command in the area configuration submode (and specify the **message-digest** keyword if you want the entire area to use MD5 authentication). This strategy requires fewer commands than specifying authentication for each interface.

Key Rollover

To support the changing of an MD5 key in an operational network without disrupting OSPF adjacencies (and hence the topology), a key rollover mechanism is supported. As a network administrator configures the new key into the multiple networking devices that communicate, some time exists when different devices are using both a new key and an old key. If an interface is configured with a new key, the software sends two copies of the same packet, each authenticated by the old key and new key. The software tracks which devices start using the new key, and the software stops sending duplicate packets after it detects that all of its neighbors are using the new key. The software then discards the old key. The network administrator must then remove the old key from each the configuration file of each router.

Neighbors and Adjacency for OSPF

Routers that share a segment (Layer 2 link between two interfaces) become neighbors on that segment. OSPF uses the hello protocol as a neighbor discovery and keep alive mechanism. The hello protocol involves receiving and periodically sending hello packets out each interface. The hello packets list all known OSPF neighbors on the interface. Routers become neighbors when they see themselves listed in the hello packet of the neighbor. After two routers are neighbors, they may proceed to exchange and synchronize their databases, which creates an adjacency. On broadcast and NBMA networks all neighboring routers have an adjacency.

Designated Router (DR) for OSPF

On point-to-point and point-to-multipoint networks, the Cisco IOS XR software floods routing updates to immediate neighbors. No DR or backup DR (BDR) exists; all routing information is flooded to each router.

On broadcast or NBMA segments only, OSPF minimizes the amount of information being exchanged on a segment by choosing one router to be a DR and one router to be a BDR. Thus, the routers on the segment have a central point of contact for information exchange. Instead of each router exchanging routing updates with every other router on the segment, each router exchanges information with the DR and BDR. The DR and BDR relay the information to the other routers. On broadcast network segments the number of OSPF packets is further reduced by the DR and BDR sending such OSPF updates to a multicast IP address that all OSPF routers on the network segment are listening on.

The software looks at the priority of the routers on the segment to determine which routers are the DR and BDR. The router with the highest priority is elected the DR. If there is a tie, then the router with the higher router ID takes precedence. After the DR is elected, the BDR is elected the same way. A router with a router priority set to zero is ineligible to become the DR or BDR.

Default Route for OSPF,

Type 5 (ASE) LSAs are generated and flooded to all areas except stub areas. For the routers in a stub area to be able to route packets to destinations outside the stub area, a default route is injected by the ABR attached to the stub area.

The cost of the default route is 1 (default) or is determined by the value specified in the **default-cost** command.

Link-State Advertisement Types for OSPF Version 2

Each of the following LSA types has a different purpose:

- Router LSA (Type 1)—Describes the links that the router has within a single area, and the cost of each link. These LSAs are flooded within an area only. The LSA indicates if the router can compute paths based on quality of service (QoS), whether it is an ABR or ASBR, and if it is one end of a virtual link. Type 1 LSAs are also used to advertise stub networks.
- Network LSA (Type 2)—Describes the link state and cost information for all routers attached a multiaccess network segment. This LSA lists all the routers that have interfaces attached to the network segment. It is the job of the designated router of a network segment to generate and track the contents of this LSA.
- Summary LSA for ABRs (Type 3)—Advertises internal networks to routers in other areas (interarea routes). Type 3 LSAs may represent a single network or a set of networks aggregated into one prefix. Only ABRs generate summary LSAs.
- Summary LSA for ASBRs (Type 4)—Advertises and ASBR and the cost to reach it. Routers that are trying to reach an external network use these advertisements to determine the best path to the next hop. ABRs generate Type 4 LSAs.
- Autonomous system external LSA (Type 5)—Redistributes routes from another autonomous system, usually from a different routing protocol into OSPF.

Link-State Advertisement Types for OSPFv3

Each of the following LSA types has a different purpose:

- Router LSA (Type 1)—Describes the link state and costs of a the router link to the area. These LSAs are flooded within an area only. The LSA indicates whether the router is an ABR or ASBR and if it is one end of a virtual link. Type 1 LSAs are also used to advertise stub networks. In OSPFv3, these LSAs have no address information and are network protocol independent. In OSPFv3, router interface information may be spread across multiple router LSAs. Receivers must concatenate all router LSAs originated by a given router before running the SPF calculation.
- Network LSA (Type 2)—Describes the link state and cost information for all routers attached to a multiaccess network segment. This LSA lists all OSPF routers that have interfaces attached to the network segment. Only the elected designated router for the network segment can generate and track the network LSA for the segment. In OSPFv3, network LSAs have no address information and are network-protocol-independent.

- Interarea-prefix LSA for ABRs (Type 3)—Advertises internal networks to routers in other areas (interarea routes). Type 3 LSAs may represent a single network or set of networks aggregated into one prefix. Only ABRs generate Type 3 LSAs. In OSPFv3, addresses for these LSAs are expressed as “prefix and prefix length” instead of “address and mask.” The default route is expressed as a prefix with length 0.
- Interarea-router LSA for ASBRs (Type 4)—Advertises an ASBR and the cost to reach it. Routers that are trying to reach an external network use these advertisements to determine the best path to the next hop. ABRs generate Type 4 LSAs.
- Autonomous system external LSA (Type 5)—Redistributes routes from another autonomous system, usually from a different routing protocol into OSPF. In OSPFv3, addresses for these LSAs are expressed as “prefix and prefix length” instead of “address and mask.” The default route is expressed as a prefix with length 0.
- Autonomous system external LSA (Type 7)—Provides for carrying external route information within an NSSA. Type 7 LSAs may be originated by and advertised throughout an NSSA. NSSAs do not receive or originate Type 5 LSAs. Type 7 LSAs are advertised only within a single NSSA. They are not flooded into the the backbone area or any otehr area by border routers.
- Link LSA (Type 8)—Has link-local flooding scope and is never flooded beyond the link with which it is associated. Link LSAs provide the link-local address of the router to all other routers attached to the link or network segment, inform other routers attached to the link of a list of IPv6 prefixes to associate with the link, and allow the router to assert a collection of Options bits to associate with the network LSA that is originated for the link.
- Intra-area-prefix LSAs (Type 9)—A router can originate multiple intra-area-prefix LSAs for every router or transit network, each with a unique link-state ID. The link-state ID for each intra-area-prefix LSA describes its association to either the router LSA or network LSA and contains prefixes for stub and transit networks.

An address prefix occurs in almost all newly defined LSAs. The prefix is represented by three fields: Prefix Length, Prefix Options, and Address Prefix. In OSPFv3, addresses for these LSAs are expressed as “prefix and prefix length” instead of “address and mask.” The default route is expressed as a prefix with length 0.

Inter-area-prefix and intra-area-prefix LSAs carry all IPv6 prefix information that, in IPv4, is included in router LSAs and network LSAs. The Options field in certain LSAs (router LSAs, network LSAs, interarea-router LSAs, and link LSAs) has been expanded to 24 bits to provide support for OSPF in IPv6.

In OSPFv3, the sole function of link-state ID in interarea-prefix LSAs, interarea-router LSAs, and autonomous system external LSAs is to identify individual pieces of the link-state database. All addresses or router IDs that are expressed by the link-state ID in OSPF Version 2 are carried in the body of the LSA in OSPFv3.

Virtual Link and Transit Area for OSPF

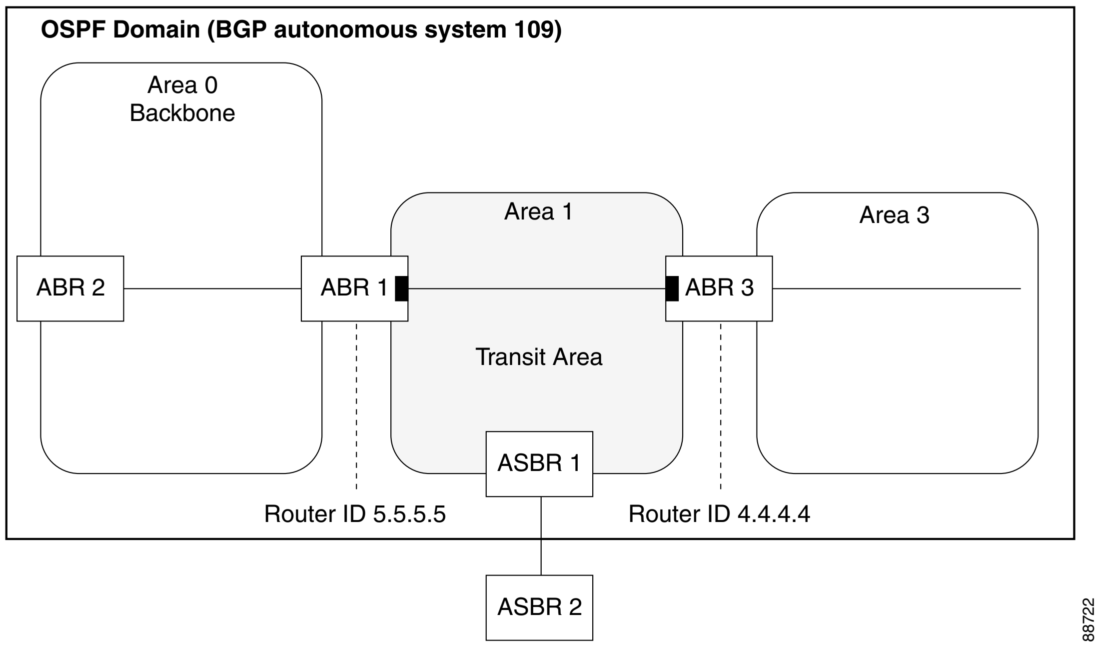
In OSPF, routing information from all areas is first summarized to the backbone area by ABRs. The same ABRs, in turn, propagate such received information to their attached areas. Such hierarchical distribution of routing information requires that all areas be connected to the backbone area (Area 0). Occasions might exist for which an area must be defined, but it cannot be physically connected to Area 0. Examples of such an occasion might be if your company makes a new acquisition that includes an OSPF area, or if Area 0 itself is partitioned.

In the case in which an area cannot be connected to Area 0, you must configure a virtual link between that area and Area 0. The two endpoints of a virtual link are ABRs, and the virtual link must be configured in both routers. The common nonbackbone area to which the two routers belong is called a transit area. A virtual link specifies the transit area and the router ID of the other virtual endpoint (the other ABR).

A virtual link cannot be configured through a stub area or NSSA.

Figure 11 illustrates a virtual link from Area 3 to Area 0.

Figure 11 Virtual Link to Area 0



Route Redistribution for OSPF

Redistribution allows different routing protocols to exchange routing information. This technique can be used to allow connectivity to span multiple routing protocols. It is important to remember that the **redistribute** command controls redistribution *into* an OSPF process and not from OSPF. See the "Configuration Examples for Implementing OSPF on Cisco IOS XR Software" section on page 236 for an example of route redistribution for OSPF.

OSPF Shortest Path First Throttling

OSPF SPF throttling makes it possible to configure SPF scheduling in millisecond intervals and to potentially delay SPF calculations during network instability. SPF is scheduled to calculate the Shortest Path Tree (SPT) when there is a change in topology. One SPF run may include multiple topology change events.

The interval at which the SPF calculations occur is chosen dynamically and based on the frequency of topology changes in the network. The chosen interval is within the boundary of the user-specified value ranges. If network topology is unstable, SPF throttling calculates SPF scheduling intervals to be longer until topology becomes stable.

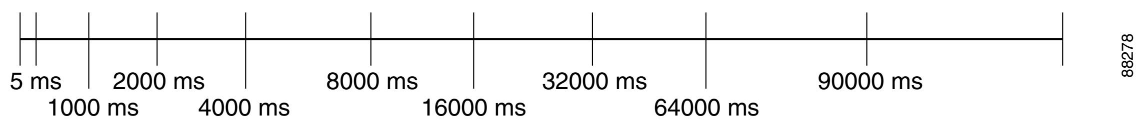
SPF calculations occur at the interval set by the **timers throttle spf** command. The wait interval indicates the amount of time to wait until the next SPF calculation occurs. Each wait interval after that calculation is twice as long as the previous interval until the interval reaches the maximum wait time specified.

The SPF timing can be better explained using an example. In this example, the start interval is set at 5 milliseconds (ms), initial wait interval at 1000 ms, and maximum wait time at 90,000 ms.

```
timers spf 5 1000 90000
```

Figure 12 shows the intervals at which the SPF calculations occur as long as at least one topology change event is received in a given wait interval.

Figure 12 SPF Calculation Intervals Set by the timers spf Command

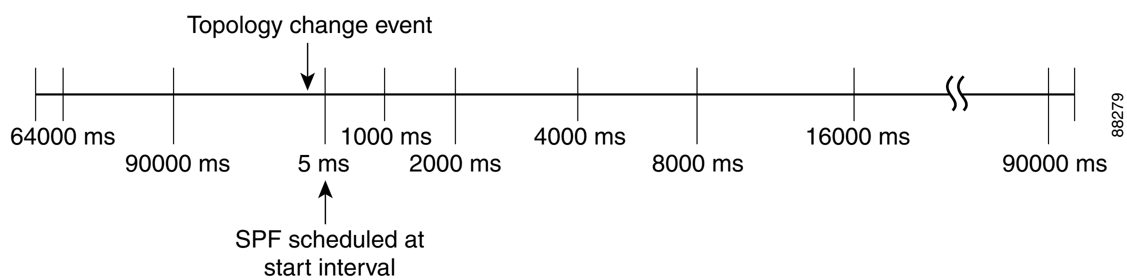


Notice that the wait interval between SPF calculations doubles when at least one topology change event is received during the previous wait interval. After the maximum wait time is reached, the wait interval remains the same until the topology stabilizes and no event is received in that interval.

If the first topology change event is received after the current wait interval, the SPF calculation is delayed by the amount of time specified as the start interval. The subsequent wait intervals continue to follow the dynamic pattern.

If the first topology change event occurs after the maximum wait interval begins, the SPF calculation is again scheduled at the start interval and subsequent wait intervals are reset according to the parameters specified in the **timers throttle spf** command. Notice in Figure 13 that a topology change event was received after the start of the maximum wait time interval and that the SPF intervals have been reset.

Figure 13 Timer Intervals Reset After Topology Change Event



Nonstop Forwarding for OSPF Version 2

Cisco IOS XR NSF for OSPF Version 2 allows for the forwarding of data packets to continue along known routes while the routing protocol information is being restored following a failover. With NSF, peer networking devices do not experience routing flaps. During failover, data traffic is forwarded

through intelligent line cards while the standby Route Processor (RP) assumes control from the failed RP. The ability of line cards to remain up through a failover and to be kept current with the Forwarding Information Base (FIB) on the active RP is key to Cisco IOS XR NSF operation.

Routing protocols, such as OSPF, run only on the active RP or DRP and receive routing updates from their neighbor routers. When an OSPF NSF-capable router performs an RP failover, it must perform two tasks to resynchronize its link-state database with its OSPF neighbors. First, it must relearn the available OSPF neighbors on the network without causing a reset of the neighbor relationship. Second, it must reacquire the contents of the link-state database for the network.

As quickly as possible after an RP failover, the NSF-capable router sends an OSPF NSF signal to neighboring NSF-aware devices. This signal is in the form of a link-local LSA generated by the failed-over router. Neighbor networking devices recognize this signal as a cue that the neighbor relationship with this router should not be reset. As the NSF-capable router receives signals from other routers on the network, it can begin to rebuild its neighbor list.

After neighbor relationships are re-established, the NSF-capable router begins to resynchronize its database with all of its NSF-aware neighbors. At this point, the routing information is exchanged between the OSPF neighbors. After this exchange is completed, the NSF-capable device uses the routing information to remove stale routes, update the RIB, and update the FIB with the new forwarding information. OSPF on the router as well as the OSPF neighbors are now fully converged.

Note The standardized IETF version of NSF, known as OSPF graceful restart (RFC 3623) is also supported.

Load Balancing in OSPF Version 2 and OSPFv3

When a router learns multiple routes to a specific network by using multiple routing processes (or routing protocols), it installs the route with the lowest administrative distance in the routing table. Sometimes the router must select a route from among many learned by using the same routing process with the same administrative distance. In this case, the router chooses the path with the lowest cost (or metric) to the destination. Each routing process calculates its cost differently; the costs may need to be manipulated to achieve load balancing.

OSPF performs load balancing automatically. If OSPF finds that it can reach a destination through more than one interface and each path has the same cost, it installs each path in the routing table. The only restriction on the number of paths to the same destination is controlled by the **maximum-paths** (OSPF) command. The default number of maximum paths is 32 for Cisco CRS-1 routers and 16 for Cisco XR 12000 Series Routers. The range is from 1 to 32 for Cisco CRS-1 routers and 1 to 16 for Cisco XR 12000 Series Routers.

How to Implement OSPF on Cisco IOS XR Software

This section contains the following procedures:

- Enabling OSPF, page RC-184 (required)
- Configuring Stub and Not-so-Stubby Area Types, page RC-186 (optional)
- Configuring Neighbors for Nonbroadcast Networks, page RC-189 (optional)
- Configuring Authentication at Different Hierarchical Levels for OSPF Version 2, page RC-194 (optional)

Enabling OSPF

This task explains how to perform the minimum OSPF configuration on your router that is to enable an OSPF process with a router ID, configure a backbone or nonbackbone area, and then assign one or more interfaces on which OSPF runs.

Prerequisites

Although you can configure OSPF before you configure an IP address, no OSPF routing occurs until at least one IP address is configured.

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
   or
   router ospfv3 *process-name*
3. **router-id** {*ipv4-address* | *interface-type interface-instance*}
4. **area** *area-id*
5. **interface** *type instance*
6. Repeat Step 5 for each interface that use OSPF.
7. **log adjacency changes** [**detail**] [**enable** | **disable**]
8. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**`configure`** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**`router ospf`** *`process-name`* or **`router ospfv3`** *`process-name`* **Example:** `RP/0/RP0/CPU0:router(config)# router ospf 1` or `RP/0/RP0/CPU0:router(config)# router ospfv3 1`	Enables OSPF routing for the specified routing process and places the router in router configuration mode. or Enables OSPFv3 routing for the specified routing process and places the router in router ospfv3 configuration mode. **Note** The *process-name* argument is any alphanumeric string no longer than 40 characters.
Step 3	**`router-id`** `{`*`ipv4-address`* `|` *`interface-type interface-instance`*`}` **Example:** `RP/0/RP0/CPU0:router(config-ospf)# router-id 192.168.4.3`	Configures a router ID for the OSPF process. **Note** We recommend using a stable IP address as the router ID.
Step 4	**`area`** *`area-id`* **Example:** `RP/0/RP0/CPU0:router(config-ospf)# area 0`	Enters area configuration mode and configures an area for the OSPF process. • Backbone areas have an area ID of 0. • Nonbackbone areas have a nonzero area ID. • The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area. We recommend using the IPv4 address notation.
Step 5	**`interface`** *`type instance`* **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# interface POS 0/1/0/3`	Enters interface configuration mode and associates one or more interfaces for the area configured in Step 4.
Step 6	Repeat Step 5 for each interface that uses OSPF.	—

	Command or Action	Purpose
Step 7	**log adjacency changes** [**detail**] [**enable** | **disable**] **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar-if)# log adjacency changes detail`	(Optional) Requests notification of neighbor changes. • By default, this feature is enabled. • The messages generated by neighbor changes are considered notifications, which are categorized as severity Level 5 in the **logging console** command. The **logging console** command controls which severity level of messages are sent to the console. By default, all severity level messages are sent.
Step 8	**end** or **commit** **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar-if)# end` or `RP/0/RP0/CPU0:router(config-ospf-ar-if)# commit`	Saves configuration changes. • When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` – Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. – Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. – Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Stub and Not-so-Stubby Area Types

This task explains how to configure the stub area and the NSSA for OSPF.

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
   or
   router ospfv3 *process-name*
3. **router-id** {*ipv4-address* | *interface-type interface-instance*}
4. **area** *area-id*
5. **stub** [**no-summary**]
   or
   nssa [**no-redistribution**] [**default-information-originate**] [**no-summary**]

6. **stub**
   or
   nssa
7. **default-cost** *cost*
8. **end**
   or
   commit
9. Repeat this task on all other routers in the stub area or NSSA.

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**router ospf** *process-name* or **router ospfv3** *process-name* **Example:** `RP/0/RP0/CPU0:router(config)# router ospf 1` or `RP/0/RP0/CPU0:router(config)# router ospfv3 1`	Enables OSPF routing for the specified routing process and places the router in router configuration mode. or Enables OSPFv3 routing for the specified routing process and places the router in router ospfv3 configuration mode. **Note** The *process-name* argument is any alphanumeric string no longer than 40 characters.
Step 3	**router-id** {*ipv4-address* | *interface-type interface-instance*} **Example:** `RP/0/RP0/CPU0:router(config-ospf)# router-id 192.168.4.3`	Configures a router ID for the OSPF process. **Note** We recommend using a stable IP address as the router ID.
Step 4	**area** *area-id* **Example:** `RP/0/RP0/CPU0:router(config-ospf)# area 1`	Enters area configuration mode and configures a nonbackbone area for the OSPF process. • The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area. We recommend using the IPv4 address notation.

	Command or Action	Purpose
Step 5	**stub** [**no-summary**] or **nssa** [**no-redistribution**] [**default-information-originate**] [**no-summary**] **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# stub no summary` or `RP/0/RP0/CPU0:router(config-ospf-ar)# nssa no-redistribution`	Defines the nonbackbone area as a stub area. • See the "Configuring Stub and Not-so-Stubby Area Types" section on page 186. • Specify the **no-summary** keyword to further reduce the number of LSAs sent into a stub area. This keyword prevents the ABR from sending summary link-state advertisements (Type 3) in the stub area. or Defines an area as an NSSA. • See the "Configuring Stub and Not-so-Stubby Area Types" section on page 186.
Step 6	**stub** or **nssa** **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# stub` or `RP/0/RP0/CPU0:router(config-ospf-ar)# nssa`	(Optional) Turns off the options configured for stub and NSSA areas. • If you configured the stub and NSSA areas using the optional keywords (**no-summary**, **no-redistribution**, **default-information-originate**, and **no-summary**) in Step 5, you must now reissue the **stub** and **nssa** commands without the keywords—rather than using the **no** form of the command. • For example, the **no nssa default-information-originate** form of the command changes the NSSA area into a normal area that inadvertently brings down the existing adjacencies in that area.
Step 7	**default-cost** *cost* **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# default-cost 15`	(Optional) Specifies a cost for the default summary route sent into a stub area or an NSSA. • Use this command only on ABRs attached to the NSSA. Do not use it on any other routers in the area. • The default cost is 1.

	Command or Action	Purpose
Step 8	**end** or **commit** **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# end` or `RP/0/RP0/CPU0:router(config-ospf-ar)# commit`	Saves configuration changes. • When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` – Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. – Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. – Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.
Step 9	Repeat this task on all other routers in the stub area or NSSA.	—

Configuring Neighbors for Nonbroadcast Networks

This task explains how to configure neighbors for a nonbroadcast network. This task is optional.

Prerequisites

Configuring NBMA networks as either broadcast or nonbroadcast assumes that there are virtual circuits from every router to every router or fully meshed network.

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
   or
   router ospfv3 *process-name*
3. **router-id** {*ipv4-address* | *interface-type interface-instance*}
4. **area** *area-id*
5. **network** {**broadcast** | **non-broadcast** | {**point-to-multipoint** [**non-broadcast**] | **point-to-point**}}
6. **dead-interval** *seconds*
7. **hello-interval** *seconds*
8. **interface** *type number*

9. **neighbor** *ip-address* [**priority** *number*] [**poll-interval** *seconds*] [**cost** *number*]
or
neighbor *ipv6-link-local-address* [**priority** *number*] [**poll-interval** *seconds*] [**cost** *number*] [**database-filter** [**all**]]
10. Repeat Step 9 for all neighbors on the interface.
11. **exit**
12. **interface** *type instance*
13. **neighbor** *ip-address* [**priority** *number*] [**poll-interval** *seconds*][**cost** *number*] [**database-filter** [**all**]]
or
neighbor *ipv6-link-local-address* [**priority** *number*] [**poll-interval** *seconds*][**cost** *number*] [**database-filter** [**all**]]
14. Repeat Step 13 for all neighbors on the interface.
15. **end**
or
commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	`configure` **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**`router ospf`** *`process-name`* or **`router ospfv3`** *`process-name`* **Example:** `RP/0/RP0/CPU0:router(config)# router ospf 1` or `RP/0/RP0/CPU0:router(config)# router ospfv3 1`	Enables OSPF routing for the specified routing process and places the router in router configuration mode. or Enables OSPFv3 routing for the specified routing process and places the router in router ospfv3 configuration mode. **Note** The *process-name* argument is any alphanumeric string no longer than 40 characters.
Step 3	**`router-id`** {*`ipv4-address`* | *`interface-type interface-instance`*} **Example:** `RP/0/RP0/CPU0:router(config-ospf)# router-id 192.168.4.3`	Configures a router ID for the OSPF process. **Note** We recommend using a stable IP address as the router ID.
Step 4	**`area`** *`area-id`* **Example:** `RP/0/RP0/CPU0:router(config-ospf)# area 0`	Enters area configuration mode and configures an area for the OSPF process. • The example configures a backbone area. • The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area. We recommend using the IPv4 address notation.

	Command or Action	Purpose
Step 5	**network** {**broadcast** | **non-broadcast** | {**point-to-multipoint** [**non-broadcast**] | **point-to-point**}} **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# network non-broadcast`	Configures the OSPF network type to a type other than the default for a given medium. • The example sets the network type to NBMA.
Step 6	**dead-interval** *seconds* **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# dead-interval 40`	(Optional) Sets the time to wait for a hello packet from a neighbor before declaring the neighbor down.
Step 7	**hello-interval** *seconds* **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# hello-interval 10`	(Optional) Specifies the interval between hello packets that OSPF sends on the interface.
Step 8	**interface** *type instance* **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# interface POS 0/2/0/0`	Enters interface configuration mode and associates one or more interfaces for the area configured in Step 4. • In this example, the interface inherits the nonbroadcast network type and the hello and dead intervals from the areas because the values are not set at the interface level.

	Command or Action	Purpose
Step 9	**neighbor** *ip-address* [**priority** *number*] [**poll-interval** *seconds*][**cost** *number*] or **neighbor** *ipv6-link-local-address* [**priority** *number*] [**poll-interval** *seconds*][**cost** *number*] [**database-filter** [**all**]] **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar-if)# neighbor 10.20.20.1 priority 3 poll-interval 15` or `RP/0/RP0/CPU0:router(config-ospf-ar-if)# neighbor fe80::3203:a0ff:fe9d:f3fe`	Configures the IPv4 address of OSPF neighbors interconnecting to nonbroadcast networks. or Configures the link-local IPv6 address of OSPFv3 neighbors. • The *ipv6-link-local-address* argument must be in the form documented in RFC 2373 in which the address is specified in hexadecimal using 16-bit values between colons. • The **priority** keyword notifies the router that this neighbor is eligible to become a DR or BDR. The priority value should match the actual priority setting on the neighbor router. The neighbor priority default value is zero. This keyword does not apply to point-to-multipoint interfaces. • The **poll-interval** keyword does not apply to point-to-multipoint interfaces. RFC 1247 recommends that this value be much larger than the hello interval. The default is 120 seconds (2 minutes). • Neighbors with no specific cost configured assumes the cost of the interface, based on the **cost** command. On point-to-multipoint interfaces, **cost** *number* is the only keyword and argument combination that works. The **cost** keyword does not apply to NBMA networks. • The **database-filter** keyword filters outgoing LSAs to an OSPF neighbor. If you specify the **all** keyword, incoming and outgoing LSAs are filtered. Use with extreme caution since filtering may cause the routing topology to be seen as entirely different between two neighbors, resulting in 'black-holing' of data traffic or routing loops.
Step 10	Repeat Step 9 for all neighbors on the interface.	—
Step 11	**exit** **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar-if)# exit`	Enters area configuration mode.
Step 12	**interface** *type instance* **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# interface POS 0/3/0/1`	Enters interface configuration mode and associates one or more interfaces for the area configured in Step 4. • In this example, the interface inherits the nonbroadcast network type and the hello and dead intervals from the areas because the values are not set at the interface level.

	Command or Action	Purpose
Step 13	**`neighbor`** *`ip-address`* `[`**`priority`** *`number`*`]` `[`**`poll-interval`** *`seconds`*`][`**`cost`** *`number`*`]` `[`**`database-filter`** `[`**`all`**`]]` or **`neighbor`** *`ipv6-link-local-address`* `[`**`priority`** *`number`*`]` `[`**`poll-interval`** *`seconds`*`][`**`cost`** *`number`*`]` `[`**`database-filter`** `[`**`all`**`]]` **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# neighbor 10.34.16.6` or `RP/0/RP0/CPU0:router(config-ospf-ar)# neighbor fe80::3203:a0ff:fe9d:f3f`	Configures the IPv4 address of OSPF neighbors interconnecting to nonbroadcast networks. or Configures the link-local IPv6 address of OSPFv3 neighbors. • The *ipv6-link-local-address* argument must be in the form documented in RFC 2373 in which the address is specified in hexadecimal using 16-bit values between colons. • The **priority** keyword notifies the router that this neighbor is eligible to become a DR or BDR. The priority value should match the actual priority setting on the neighbor router. The neighbor priority default value is zero. This keyword does not apply to point-to-multipoint interfaces. • The **poll-interval** keyword does not apply to point-to-multipoint interfaces. RFC 1247 recommends that this value be much larger than the hello interval. The default is 120 seconds (2 minutes). • Neighbors with no specific cost configured assumes the cost of the interface, based on the **cost** command. On point-to-multipoint interfaces, **cost** *number* is the only keyword and argument combination that works. The **cost** keyword does not apply to NBMA networks. • The **database-filter** keyword filters outgoing LSAs to an OSPF neighbor. If you specify the **all** keyword, incoming and outgoing LSAs are filtered. Use with extreme caution since filtering may cause the routing topology to be seen as entirely different between two neighbors, resulting in 'black-holing' or routing loops.

	Command or Action	Purpose
Step 14	Repeat Step 13 for all neighbors on the interface.	—
Step 15	**`end`** or **`commit`** **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# end` or `RP/0/RP0/CPU0:router(config-ospf-ar)# commit`	Saves configuration changes. • When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` – Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. – Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. – Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Authentication at Different Hierarchical Levels for OSPF Version 2

This task explains how to configure MD5 (secure) authentication on the OSPF router process, configure one area with plain text authentication, and then apply one interface with clear text (null) authentication.

Note Authentication configured at the interface level overrides authentication configured at the area level and the router process level. If an interface does not have authentication specifically configured, the interface inherits the authentication parameter value from a higher hierarchical level. See the "OSPF Hierarchical CLI and CLI Inheritance" section on page 173 for more information about hierarchy and inheritance.

Prerequisites

If you choose to configure authentication, you must first decide whether to configure plain text or MD5 authentication, and whether the authentication applies to all interfaces in a process, an entire area, or specific interfaces. See the "Route Authentication Methods for OSPF Version 2" section on page 177 for information about each type of authentication and when you should use a specific method for your network.

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
3. **router-id** {*ipv4-address* | *interface-type interface-instance*}
4. **authentication** [**message-digest** | **null**]

5. **message-digest-key** *key-id* **md5** {*key* | **clear** *key* | **encrypted** *key*}
6. **area** *area-id*
7. **interface** *type instance*
8. Repeat Step 7 for each interface that must communicate, using the same authentication.
9. **exit**
10. **area** *area-id*
11. **authentication** [**message-digest** | **null**]
12. **interface** *type instance*
13. Repeat Step 7 for each interface that must communicate, using the same authentication.
14. **interface** *type instance*
15. **authentication** [**message-digest** | **null**]
16. **end**
    or
    commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** RP/0/RP0/CPU0:router# configure	Enters global configuration mode.
Step 2	**router ospf** *process-name* **Example:** RP/0/RP0/CPU0:router(config)# router ospf 1	Enables OSPF routing for the specified routing process and places the router in router configuration mode. **Note** The *process-name* argument is any alphanumeric string no longer than 40 characters.
Step 3	**router-id** {*ipv4-address* | *interface-type interface-instance*} **Example:** RP/0/RP0/CPU0:router(config-ospf)# router-id 192.168.4.3	Configures a router ID for the OSPF process.
Step 4	**authentication** [**message-digest** | **null**] **Example:** RP/0/RP0/CPU0:router(config-ospf)# authentication message-digest	Enables MD5 authentication for the OSPF process. • This authentication type applies to the entire router process unless overridden by a lower hierarchical level such as the area or interface.
Step 5	**message-digest-key** *key-id* **md5** {*key* | **clear** *key* | **encrypted** *key*} **Example:** RP/0/RP0/CPU0:router(config-ospf)# message-digest-key 4 md5 yourkey	Specifies the MD5 authentication key for the OSPF process. • The neighbor routers must have the same key identifier.

	Command or Action	Purpose
Step 6	**area** *area-id* **Example:** `RP/0/RP0/CPU0:router(config-ospf)# area 0`	Enters area configuration mode and configures a backbone area for the OSPF process.
Step 7	**interface** *type instance* **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# interface POS 0/1/0/3`	Enters interface configuration mode and associates one or more interfaces to the backbone area. • All interfaces inherit the authentication parameter values specified for the OSPF process (Step 4, Step 5, and Step 6).
Step 8	Repeat Step 7 for each interface that must communicate, using the same authentication.	—
Step 9	**exit** **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# exit`	Enters area OSPF configuration mode.
Step 10	**area** *area-id* **Example:** `RP/0/RP0/CPU0:router(config-ospf)# area 1`	Enters area configuration mode and configures a nonbackbone area 1 for the OSPF process. • The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area. We recommend using the IPv4 address notation.
Step 11	**authentication** [**message-digest** | **null**] **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# authentication`	Enables Type 1 (plain text) authentication that provides no security. • The example specifies plain text authentication (by not specifying a keyword). Use the **authentication-key** interface command to specify the plain text password.
Step 12	**interface** *type instance* **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# interface POS 0/1/0/0`	Enters interface configuration mode and associates one or more interfaces to the nonbackbone area 1 specified in Step 7. • All interfaces configured inherit the authentication parameter values configured for area 1.
Step 13	Repeat Step 12 for each interface that must communicate, using the same authentication.	—
Step 14	**interface** *type instance* **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# interface POS 0/3/0/0`	Enters interface configuration mode and associates one or more interfaces to a different authentication type.

	Command or Action	Purpose
Step 15	**authentication** [**message-digest** | **null**] **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar-if)# authentication null`	Specifies no authentication on POS interface 0/3/0/0, overriding the plain text authentication specified for area 1. • By default, all of the interfaces configured in the same area inherit the same authentication parameter values of the area.
Step 16	**end** or **commit** **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar-if)# end` or `RP/0/RP0/CPU0:router(config-ospf-ar-if)# commit`	Saves configuration changes. • When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` – Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. – Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. – Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Controlling the Frequency that the Same LSA Is Originated or Accepted for OSPF

This task explains how to tune the convergence time of OSPF routes in the routing table when many LSAs need to be flooded in a very short time interval.

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
   or
   router ospfv3 *process-name*
3. **router-id** {*ipv4-address* | *interface-type interface-instance*}
4. Perform Step 5 or Step 6 or both to control the frequency that the same LSA is originated or accepted.
5. **timers lsa gen-interval** *seconds*
6. **timers lsa min-arrival** *seconds*
7. **timers lsa group-pacing** *seconds*

8. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**`configure`** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**`router ospf`** *`process-name`* or **`router ospfv3`** *`process-name`* **Example:** `RP/0/RP0/CPU0:router(config)# router ospf 1` or `RP/0/RP0/CPU0:router(config)# router ospfv3 1`	Enables OSPF routing for the specified routing process and places the router in router configuration mode. or Enables OSPFv3 routing for the specified routing process and places the router in router ospfv3 configuration mode. **Note** The *process-name* argument is any alphanumeric string no longer than 40 characters.
Step 3	**`router-id`** `{`*`ipv4-address`* `|` *`interface-type interface-instance`*`}` **Example:** `RP/0/RP0/CPU0:router(config-ospf)# router-id 192.168.4.3`	Configures a router ID for the OSPF process. **Note** We recommend using a stable IP address as the router ID.
Step 4	Perform Step 5 or Step 6 or both to control the frequency that the same LSA is originated or accepted.	—
Step 5	**`timers lsa gen-interval`** *`seconds`* **Example:** `RP/0/RP0/CPU0:router(config-ospf)# timers lsa gen-interval 10`	Changes the minimum interval between the same OSPF LSAs that the router originates. • The default is 5 seconds for both OSPF and OSPFv3.
Step 6	**`timers lsa min-arrival`** *`seconds`* **Example:** `RP/0/RP0/CPU0:router(config-ospf)# timers lsa min-arrival 2`	Limits the frequency that new processes of any particular OSPF Version 2 LSA can be accepted during flooding. • The default is 1 second.

	Command or Action	Purpose
Step 7	**timers lsa group-pacing** *seconds* **Example:** `RP/0/RP0/CPU0:router(config-ospf)# timers lsa group-pacing 1000`	Changes the interval at which OSPF link-state LSAs are collected into a group for flooding. • The default is 240 seconds.
Step 8	**end** or **commit** **Example:** `RP/0/RP0/CPU0:router(config-ospf)# end` or `RP/0/RP0/CPU0:router(config-ospf)# commit`	Saves configuration changes. • When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` – Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. – Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. – Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Creating a Virtual Link with MD5 Authentication to Area 0 for OSPF

This task explains how to create a virtual link to your backbone (area 0) and apply MD5 authentication. You must perform the steps described on both ABRs, one at each end of the virtual link. To understand virtual links, see the "Virtual Link and Transit Area for OSPF" section on page 180.

Note After you explicitly configure area parameter values, they are inherited by all interfaces bound to that area—unless you override the values and configure them explicitly for the interface. An example is provided in the "Virtual Link Configured with MD5 Authentication for OSPF Version 2: Example" section on page 241.

Prerequisites

The following prerequisites must be met before creating a virtual link with MD5 authentication to area 0:

- You must have the router ID of the neighbor router at the opposite end of the link to configure the local router. You can execute the **show ospf** or **show ospfv3** command on the remote router to get its router ID.

- For a virtual link to be successful, you need a stable router ID at each end of the virtual link. You do not want them to be subject to change, which could happen if they are assigned by default (See the "OSPF Process and Router ID" section on page 176 for an explanation of how the router ID is determined.) Therefore, we recommend that you perform one of the following tasks before configuring a virtual link:
  - Use the **router-id** command to set the router ID. This strategy is preferable.
  - Configure a loopback interface so that the router has a stable router ID.
- Before configuring your virtual link for OSPF Version 2, you must decide whether to configure plain text authentication, MD5 authentication, or no authentication (which is the default). Your decision determines whether you need to perform additional tasks related to authentication.

Note If you decide to configure plain text authentication or no authentication, see the **authentication** command provided in the *OSPF Commands on Cisco IOS XR Software* module in the *Cisco IOS XR Routing Command Reference*.

SUMMARY STEPS

1. **show ospf** [*process-name*]
   or
   show ospfv3 [*process-name*]
2. **configure**
3. **router ospf** *process-name*
   or
   router ospfv3 *process-name*
4. **router-id** {*ipv4-address* | *interface-type interface-instance*}
5. **area** *area-id*
6. **virtual link** *router-id*
7. **authentication message-digest**
8. **message-digest-key** *key-id* **md5** {*key* | **clear** *key* | **encrypted** *key*}
9. Repeat all of the steps in this task on the ABR that is at the other end of the virtual link. Specify the same key ID and key that you specified for the virtual link on this router.
10. **end**
    or
    commit
11. **show ospf** [*process-name*] [*area-id*] **virtual-links**
    or
    show ospfv3 [*process-name*] **virtual-links**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**show ospf** [*process-name*] or **show ospfv3** [*process-name*] **Example:** `RP/0/RP0/CPU0:router# show ospf` or `RP/0/RP0/CPU0:router# show ospfv3`	(Optional) Displays general information about OSPF routing processes. • The output displays the router ID of the local router. You need this router ID to configure the other end of the link.
Step 2	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 3	**router ospf** *process-name* or **router ospfv3** *process-name* **Example:** `RP/0/RP0/CPU0:router(config)# router ospf 1` or `RP/0/RP0/CPU0:router(config)# router ospfv3 1`	Enables OSPF routing for the specified routing process and places the router in router configuration mode. or Enables OSPFv3 routing for the specified routing process and places the router in router ospfv3 configuration mode. **Note** The *process-name* argument is any alphanumeric string no longer than 40 characters.
Step 4	**router-id** {*ipv4-address* | *interface-type interface-instance*} **Example:** `RP/0/RP0/CPU0:router(config-ospf)# router-id 192.168.4.3`	Configures a router ID for the OSPF process. **Note** We recommend using a stable IPv4 address as the router ID.
Step 5	**area** *area-id* **Example:** `RP/0/RP0/CPU0:router(config-ospf)# area 1`	Enters area configuration mode and configures a nonbackbone area for the OSPF process. • The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area. We recommend using the IPv4 address notation.
Step 6	**virtual-link** *router-id* **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# virtual link 10.3.4.5`	Defines an OSPF virtual link. • See the "Virtual Link and Transit Area for OSPF" section on page 180.
Step 7	**authentication message-digest** **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar-vl)# authentication message-digest`	Selects MD5 authentication for this virtual link.

	Command or Action	Purpose
Step 8	**message-digest-key** *key-id* **md5** {*key* | **clear** *key* | **encrypted** *key*} **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar-vl)# message-digest-key 4 md5 yourkey`	Defines an OSPF virtual link. • See the "Virtual Link and Transit Area for OSPF" section on page 180 to understand a virtual link. • The *key-id* argument is a number in the range from 1 to 255. The *key* argument is an alphanumeric string of up to 16 characters. The routers at both ends of the virtual link must have the same key identifier and key to be able to route OSPF traffic. • The **authentication-key** *key* command is not supported for OSPFv3. • Once the key is encrypted it must remain encrypted.
Step 9	Repeat all of the steps in this task on the ABR that is at the other end of the virtual link. Specify the same key ID and key that you specified for the virtual link on this router.	—
Step 10	**end** or **commit** **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar-vl)# end` or `RP/0/RP0/CPU0:router(config-ospf-ar-vl)# commit`	Saves configuration changes. • When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` – Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. – Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. – Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.
Step 11	**show ospf** [*process-name*] [*area-id*] **virtual-links** or **show ospfv3** [*process-name*] **virtual-links** **Example:** `RP/0/RP0/CPU0:router# show ospf 1 2 virtual-links` or `RP/0/RP0/CPU0:router# show ospfv3 1 virtual-links`	(Optional) Displays the parameters and the current state of OSPF virtual links.

Examples

In the following example, the **show ospfv3 virtual links** EXEC command verifies that the OSPF_VL0 virtual link to the OSPFv3 neighbor is up, the ID of the virtual link interface is 2, and the IPv6 address of the virtual link endpoint is 2003:3000::1.

```
RP/0/RP0/CPU0:router# show ospfv3 virtual-links

Virtual Links for OSPFv3 1

Virtual Link OSPF_VL0 to router 10.0.0.3 is up
  Interface ID 2, IPv6 address 2003:3000::1
  Run as demand circuit
  DoNotAge LSA allowed.
  Transit area 0.1.20.255, via interface POS 0/1/0/1, Cost of using 2
  Transmit Delay is 5 sec, State POINT_TO_POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:02
    Adjacency State FULL (Hello suppressed)
    Index 0/2/3, retransmission queue length 0, number of retransmission 1
    First 0(0)/0(0)/0(0) Next 0(0)/0(0)/0(0)
    Last retransmission scan length is 1, maximum is 1
    Last retransmission scan time is 0 msec, maximum is 0 msec

Check for lines:
Virtual Link OSPF_VL0 to router 10.0.0.3 is up
    Adjacency State FULL (Hello suppressed)

State is up and Adjacency State is FULL
```

Summarizing Subnetwork LSAs on an OSPF ABR

If you configured two or more subnetworks when you assigned your IP addresses to your interfaces, you might want the software to summarize (aggregate) into a single LSA all of the subnetworks that the local area advertises to another area. Such summarization would reduce the number of LSAs and thereby conserve network resources. This summarization is known as interarea route summarization. It applies to routes from within the autonomous system. It does not apply to external routes injected into OSPF by way of redistribution.

This task configures OSPF to summarize subnetworks into one LSA, by specifying that all subnetworks that fall into a range are advertised together. This task is performed on an ABR only.

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
   or
   router ospfv3 *process-name*
3. **router-id** {*ipv4-address* | *interface-type interface-instance*}
4. **area** *area-id*
5. **range** *ip-address mask* [**advertise** | **not-advertise**]
   or
   range *ipv6-prefix*/*prefix-length* [**advertise** | **not-advertise**]
6. **interface** *type instance*

7. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**`configure`** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**`router ospf`** *`process-name`* or **`router ospfv3`** *`process-name`* **Example:** `RP/0/RP0/CPU0:router(config)# router ospf 1` or `RP/0/RP0/CPU0:router(config)# router ospfv3 1`	Enables OSPF routing for the specified routing process and places the router in router configuration mode. or Enables OSPFv3 routing for the specified routing process and places the router in router ospfv3 configuration mode. **Note** The *process-name* argument is any alphanumeric string no longer than 40 characters.
Step 3	**`router-id`** {*`ipv4-address`* | *`interface-type interface-instance`*} **Example:** `RP/0/RP0/CPU0:router(config-ospf)# router-id 192.168.4.3`	Configures a router ID for the OSPF process. **Note** We recommend using a stable IPv4 address as the router ID.
Step 4	**`area`** *`area-id`* **Example:** `RP/0/RP0/CPU0:router(config-ospf)# area 0`	Enters area configuration mode and configures a nonbackbone area for the OSPF process. • The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area. We recommend using the IPv4 address notation.
Step 5	**`range`** *`ip-address mask`* [**`advertise`** | **`not-advertise`**] or **`range`** *`ipv6-prefix`*/*`prefix-length`* [**`advertise`** | **`not-advertise`**] **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# range 192.168.0.0 255.255.0.0 advertise` or **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# range 4004:f000::/32 advertise`	Consolidates and summarizes OSPF routes at an area boundary. • The **advertise** keyword causes the software to advertise the address range of subnetworks in a Type 3 summary LSA. • The **not-advertise** keyword causes the software to suppress the Type 3 summary LSA, and the subnetworks in the range remain hidden from other areas. • In the first example, all subnetworks for network 192.168.0.0 are summarized and advertised by the ABR into areas outside the backbone. • In the second example, two or more IPv4 interfaces are covered by a 192.*x.x* network.

	Command or Action	Purpose
Step 6	`interface` *type instance* **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# interface POS 0/2/0/3`	Enters interface configuration mode and associates one or more interfaces to the area.
Step 7	`end` or `commit` **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# end` or `RP/0/RP0/CPU0:router(config-ospf-ar)# commit`	Saves configuration changes. • When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` – Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. – Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. – Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Redistributing Routes from One IGP into OSPF

This task redistributes routes from an IGP (could be a different OSPF process) into OSPF.

Prerequisites

For information about configuring routing policy, see the *Implementing Routing Policy on Cisco IOS XR Software* module.

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
   or
   router ospfv3 *process-name*
3. **router-id** {*ipv4-address* | *interface-type interface-instance*}
4. **redistribute** *protocol* [*process-id*] {**level-1** | **level-1-2** | **level-2**} [**metric** *metric-value*] [**metric-type** *type-value*] [**match** {**internal** | **external** [**1** | **2**} | **nssa-external** [**1** | **2**}] [**tag** *tag-value*] [**route-map** *map-tag* | **route-policy** *policy-tag*]

5. **summary-prefix** *address mask* [**not-advertise**] [**tag** *tag*]
   or
   summary-prefix *ipv6-prefix*/*prefix-length* [**not-advertise**] [**tag** *tag*]
6. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	`configure` **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	`router ospf` *process-name* or `router ospfv3` *process-name* **Example:** `RP/0/RP0/CPU0:router(config)# router ospf 1` or `RP/0/RP0/CPU0:router(config)# router ospfv3 1`	Enables OSPF routing for the specified routing process and places the router in router configuration mode. or Enables OSPFv3 routing for the specified routing process and places the router in router ospfv3 configuration mode. **Note** The *process-name* argument is any alphanumeric string no longer than 40 characters.
Step 3	`router-id` {*ipv4-address* | *interface-type interface-instance*} **Example:** `RP/0/RP0/CPU0:router(config-ospf)# router-id 192.168.4.3`	Configures a router ID for the OSPF process. **Note** We recommend using a stable IPv4 address as the router ID.

	Command or Action	Purpose
Step 4	**redistribute** *protocol* [*process-id*] {**level-1** | **level-1-2** | **level-2**} [**metric** *metric-value*] [**metric-type** *type-value*] [**match** {**internal** | **external** [**1** | **2**} | **nssa-external** [**1** | **2**}] [**tag** *tag-value*] [**route-map** *map-tag* | **policy** *policy-tag*] **Example:** `RP/0/RP0/CPU0:router(config-ospf)# redistribute bgp 1 level-1` or `RP/0/RP0/CPU0:router(config-router)# redistribute bgp 1 level-1-2 metric-type 1`	Redistributes OSPF routes from one routing domain to another routing domain. or Redistributes OSPFv3 routes from one routing domain to another routing domain. • This command causes the router to become an ASBR by definition. • OSPF tags all routes learned through redistribution as external. • The protocol and its process ID, if it has one, indicate the protocol being redistributed into OSPF. • The metric is the cost you assign to the external route. The default is 20 for all protocols except BGP, whose default metric is 1. • The OSPF example redistributes BGP autonomous system 1, Level 1 routes into OSPF as Type 2 external routes. • The OSPFv3 example redistributes BGP autonomous system 1, Level 1 and 2 routes into OSPF. The external link type associated with the default route advertised into the OSPFv3 routing domain is the Type 1 external route. **Note** RPL is not supported for OSPFv3.

	Command or Action	Purpose
Step 5	**summary-prefix** *address mask* [**not-advertise**] [**tag** *tag*] or **summary-prefix** *ipv6-prefix*/*prefix-length* [**not-advertise**] [**tag** *tag*] **Example:** `RP/0/RP0/CPU0:router(config-ospf)# summary-prefix 10.1.0.0 255.255.0.0` or `RP/0/RP0/CPU0:router(config-router)# summary-prefix 2010:11:22::/32`	(Optional) Creates aggregate addresses for OSPF. or (Optional) Creates aggregate addresses for OSPFv3. • This command provides external route summarization of the non-OSPF routes. • External ranges that are being summarized should be contiguous. Summarization of overlapping ranges from two different routers could cause packets to be sent to the wrong destination. • This command is optional. If you do not specify it, each route is included in the link-state database and advertised in LSAs. • In the OSPFv2 example, the summary address 10.1.0.0 includes address 10.1.1.0, 10.1.2.0, 10.1.3.0, and so on. Only the address 10.1.0.0 is advertised in an external LSA. • In the OSPFv3 example, the summary address 2010:11:22::/32 has addresses such as 2010:11:22:0:1000::1, 2010:11:22:0:2000:679:1, and so on. Only the address 2010:11:22::/32 is advertised in the external LSA.
Step 6	**end** or **commit** **Example:** `RP/0/RP0/CPU0:router(config-ospf)# end` or `RP/0/RP0/CPU0:router(config-ospf)# commit`	Saves configuration changes. • When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` – Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. – Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. – Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring OSPF Shortest Path First Throttling

This task explains how to configure SPF scheduling in millisecond intervals and potentially delay SPF calculations during times of network instability. This task is optional.

Prerequisites

See the "OSPF Shortest Path First Throttling" section on page 181 for information about OSPF SPF throttling.

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
   or
   router ospfv3 *process-name*
3. **router-id** {*ipv4-address* | *interface-type interface-instance*}
4. **timers throttle spf** *spf-start spf-hold spf-max-wait*
5. **area** *area-id*
6. **interface** *type instance*
7. **end**
   or
   commit
8. **show ospf** [*process-name*]
   or
   show ospfv3 [*process-name*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**`configure`** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**`router ospf`** *`process-name`* or **`router ospfv3`** *`process-name`* **Example:** `RP/0/RP0/CPU0:router(config)# router ospf 1` or `RP/0/RP0/CPU0:router(config)# router ospfv3 1`	Enables OSPF routing for the specified routing process and places the router in router configuration mode. or Enables OSPFv3 routing for the specified routing process and places the router in router ospfv3 configuration mode. **Note** The *process-name* argument is any alphanumeric string no longer than 40 characters.

	Command or Action	Purpose
Step 3	**`router-id`** {*`ipv4-address`* | *`interface-type interface-instance`*} **Example:** `RP/0/RP0/CPU0:router(config-ospf)# router-id 192.168.4.3`	Configures a router ID for the OSPF process. **Note** We recommend using a stable IPv4 address as the router ID.
Step 4	**`timers throttle spf`** *`spf-start spf-hold spf-max-wait`* **Example:** `RP/0/RP0/CPU0:router(config-ospf)# timers throttle spf 10 4800 90000`	Sets SPF throttling timers.
Step 5	**`area`** *`area-id`* **Example:** `RP/0/RP0/CPU0:router(config-ospf)#  area 0`	Enters area configuration mode and configures a backbone area. • The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area. We recommend using the IPv4 address notation.
Step 6	**`interface`** *`type instance`* **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# interface POS 0/1/0/3`	Enters interface configuration mode and associates one or more interfaces to the area.

	Command or Action	Purpose
Step 7	**end** or **commit** **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar-if)# end` or `RP/0/RP0/CPU0:router(config-ospf-ar-if)# commit`	Saves configuration changes. • When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` – Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. – Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. – Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.
Step 8	**show ospf** [*process-name*] or **show ospfv3** [*process-name*] **Example:** `RP/0/RP0/CPU0:router# show ospf 1` or `RP/0/RP0/CPU0:router# show ospfv3 2`	(Optional) Displays SPF throttling timers.

Examples

In the following example, the **show ospf** EXEC command is used to verify that the initial SPF schedule delay time, minimum hold time, and maximum wait time are configured correctly. Additional details are displayed about the OSPF process, such as the router type and redistribution of routes.

```
RP/0/RP0/CPU0:router# show ospf 1

Routing Process "ospf 1" with ID 192.168.4.3
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 It is an autonomous system boundary router
 Redistributing External Routes from,
    ospf 2
 Initial SPF schedule delay 5 msecs
 Minimum hold time between two consecutive SPFs 100 msecs
 Maximum wait time between two consecutive SPFs 1000 msecs
 Minimum LSA interval 5 secs. Minimum LSA arrival 1 secs
 Number of external LSA 0. Checksum Sum 00000000
 Number of opaque AS LSA 0. Checksum Sum 00000000
 Number of DCbitless external and opaque AS LSA 0
 Number of DoNotAge external and opaque AS LSA 0
 Number of areas in this router is 1. 1 normal 0 stub 0 nssa
 External flood list length 0
```

```
Non-Stop Forwarding enabled
```

Note For a description of each output display field, see the **show ospf** command in the *OSPF Commands on Cisco IOS XR Software* module in the *Cisco IOS XR Routing Command Reference* document.

Configuring Nonstop Forwarding for OSPF Version 2

This task explains how to configure OSPF NSF on your NSF-capable router. This task is optional.

Prerequisites

OSPF NSF requires that all neighbor networking devices be NSF aware, which happens automatically after you install the Cisco IOS XR image on the router. If an NSF-capable router discovers that it has non-NSF-aware neighbors on a particular network segment, it disables NSF capabilities for that segment. Other network segments composed entirely of NSF-capable or NSF-aware routers continue to provide NSF capabilities.

See the "Nonstop Forwarding for OSPF Version 2" section on page 182 for conceptual information.

Restrictions

The following are restrictions when configuring nonstop forwarding:

- OSPF Cisco NSF for virtual links is not supported.
- Neighbors must be NSF aware.

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
3. **router-id** {*ipv4-address* | *interface-type interface-instance*}
4. **nsf**
   or
   nsf enforce global
5. **nsf interval** *seconds*
6. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**router ospf** *process-name* **Example:** `RP/0/RP0/CPU0:router(config)# router ospf 1`	Enables OSPF routing for the specified routing process and places the router in router configuration mode. **Note** The *process-name* argument is any alphanumeric string no longer than 40 characters.
Step 3	**router-id** {*ipv4-address* | *interface-type interface-instance*} **Example:** `RP/0/RP0/CPU0:router(config-ospf)# router-id 192.168.4.3`	Configures a router ID for the OSPF process. **Note** We recommend using a stable IPv4 address as the router ID.
Step 4	**nsf** or **nsf enforce global** **Example:** `RP/0/RP0/CPU0:router(config-ospf)# nsf` or `RP/0/RP0/CPU0:router(config-ospf)# nsf enforce global`	Enables OSPF NSF operations. • Use the **nsf** command without the optional **enforce** and **global** keywords to abort the NSF restart mechanism on the interfaces of detected non-NSF neighbors and allow NSF neighbors to function properly. • Use the **nsf** command with the optional **enforce** and **global** keywords if the router is expected to perform NSF during restart. However, if non-NSF neighbors are detected, NSF restart is canceled for the entire OSPF process.

	Command or Action	Purpose
Step 5	**nsf interval** *seconds* **Example:** `RP/0/RP0/CPU0:router(config-ospf)# nsf interval 120`	Sets the minimum time between NSF restart attempts. **Note** When you use this command, the OSPF process must be up for at least 90 seconds before OSPF attempts to perform an NSF restart.
Step 6	**end** or **commit** **Example:** `RP/0/RP0/CPU0:router(config-ospf)# end` or `RP/0/RP0/CPU0:router(config-ospf)# commit`	Saves configuration changes. • When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` – Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. – Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. – Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring OSPF Version 2 for MPLS Traffic Engineering

This task explains how to configure OSPF for MPLS TE. This task is optional.

For a description of the MPLS TE tasks and commands that allow you to configure the router to support tunnels, configure an MPLS tunnel that OSPF can use, and troubleshoot MPLS TE, see the *Implementing MPLS Traffic Engineering Configuration Guide.*

Prerequisites

Your network must support the following Cisco IOS XR features before you enable MPLS TE for OSPF on your router:

- MPLS
- IP Cisco Express Forwarding (CEF)

Note You must enter the commands in the following task on every OSPF router in the traffic-engineered portion of your network.

Restrictions

MPLS traffic engineering currently supports only a single OSPF area.

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
3. **router-id** {*ipv4-address* | *interface-type interface-instance*}
4. **mpls traffic-eng area** *area-id*
5. **mpls traffic-eng router-id** {*ip-address* | *interface-type interface-instance*}
6. **area** *area-id*
7. **interface** *type instance*
8. **end**
   or
   commit
9. **show ospf** [*process-name*] [*area-id*] **mpls traffic-eng** {**link** | **fragment**}

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**router ospf** *process-name* **Example:** `RP/0/RP0/CPU0:router(config)# router ospf 1`	Enables OSPF routing for the specified routing process and places the router in router configuration mode. **Note** The *process-name* argument is any alphanumeric string no longer than 40 characters.
Step 3	**router-id** {*ipv4-address* | *interface-type interface-instance*} **Example:** `RP/0/RP0/CPU0:router(config-ospf)# router-id 192.168.4.3`	Configures a router ID for the OSPF process. **Note** We recommend using a stable IPv4 address as the router ID.
Step 4	**mpls traffic-eng area** *area-id* **Example:** `RP/0/RP0/CPU0:router(config-ospf)# mpls traffic-eng area 0`	Configures the OSPF area for MPLS TE.

	Command or Action	Purpose
Step 5	**`mpls traffic-eng router-id`** {*`ip-address`* | *`interface-type interface-instance`*} **Example:** `RP/0/RP0/CPU0:router(config-ospf)# mpls traffic-eng router-id loopback 0`	(Optional) Specifies that the traffic engineering router identifier for the node is the IP address associated with a given interface. • This IP address is flooded to all nodes in TE LSAs. • For all traffic engineering tunnels originating at other nodes and ending at this node, you must set the tunnel destination to the traffic engineering router identifier of the destination node because that is the address that the traffic engineering topology database at the tunnel head uses for its path calculation. • We recommend that loopback interfaces be used for MPLS TE router ID because they are more stable than physical interfaces.
Step 6	**`area`** *`area-id`* **Example:** `RP/0/RP0/CPU0:router(config-ospf)# area 0`	Enters area configuration mode and configures an area for the OSPF process. • The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area.
Step 7	**`interface`** *`type instance`* **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# interface interface loopback0`	Enters interface configuration mode and associates one or more interfaces to the area.

	Command or Action	Purpose
Step 8	**end** or **commit** **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar-if)# end` or `RP/0/RP0/CPU0:router(config-ospf-ar-if)# commit`	Saves configuration changes. • When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` – Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. – Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. – Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.
Step 9	**show ospf** [*process-name*] [*area-id*] **mpls traffic-eng** {**link** | **fragment**} **Example:** `RP/0/RP0/CPU0:router# show ospf 1 0 mpls traffic-eng link`	(Optional) Displays information about the links and fragments available on the local router for MPLS TE.

Examples

This section provides the following output examples:

- Sample Output for the show ospf Command Before Configuring MPLS TE, page RC-217
- Sample Output for the show ospf mpls traffic-eng Command, page RC-218
- Sample Output for the show ospf Command After Configuring MPLS TE, page RC-219

Sample Output for the show ospf Command Before Configuring MPLS TE

In the following example, the **show route ospf** EXEC command verifies that POS interface 0/3/0/0 exists and MPLS TE is not configured:

```
RP/0/RP0/CPU0:router# show route ospf 1 0

O E2 192.168.10.0/24 [110/20] via 192.168.1.2, 00:02:50, POS 0/3/0/0
                [110/20] via 192.168.4.1, 00:02:50, POS 0/3/0/1
O E2 192.168.11.0/24 [110/20] via 192.168.1.2, 00:02:50, POS 0/3/0/0
                [110/20] via 192.168.4.1, 00:02:50, POS 0/3/0/1
O E2 192.168.244.0/24 [110/20] via 192.168.1.2, 00:02:50, POS 0/3/0/0
                   [110/20] via 192.168.4.1, 00:02:50, POS 0/3/0/1
O    192.168.12.0/24 [110/2] via 192.168.1.2, 00:02:50, POS 0/3/0/0
                    [110/2] via 192.168.4.1, 00:02:50, POS 0/3/0/1
```

Sample Output for the show ospf mpls traffic-eng Command

In the following example, the **show ospf mpls traffic-eng** EXEC command verifies that the MPLS TE fragments are configured correctly:

```
RP/0/RP0/CPU0:router# show ospf 1 mpls traffic-eng fragment

OSPF Router with ID (192.168.4.3) (Process ID 1)

  Area 0 has 1  MPLS TE fragment. Area instance is 3.
  MPLS router address is 192.168.4.2
  Next fragment ID is 1

  Fragment 0 has 1 link. Fragment instance is 3.
  Fragment has 0 link the same as last update.
  Fragment advertise MPLS router address
    Link is associated with fragment 0. Link instance is 3
      Link connected to Point-to-Point network
      Link ID :55.55.55.55
      Interface Address :192.168.50.21
      Neighbor Address :192.168.4.1
      Admin Metric :0
      Maximum bandwidth :19440000
      Maximum global pool reservable bandwidth :25000000
      Maximum sub pool reservable bandwidth    :3125000
      Number of Priority :8
      Global pool unreserved BW
      Priority 0 :  25000000  Priority 1 :  25000000
      Priority 2 :  25000000  Priority 3 :  25000000
      Priority 4 :  25000000  Priority 5 :  25000000
      Priority 6 :  25000000  Priority 7 :  25000000
      Sub pool unreserved BW
      Priority 0 :   3125000  Priority 1 :   3125000
      Priority 2 :   3125000  Priority 3 :   3125000
      Priority 4 :   3125000  Priority 5 :   3125000
      Priority 6 :   3125000  Priority 7 :   3125000
      Affinity Bit :0
```

In the following example, the **show ospf mpls traffic-eng** EXEC command verifies that the MPLS TE links on area instance 3 are configured correctly:

```
RP/0/RP0/CPU0:router# show ospf mpls traffic-eng link

            OSPF Router with ID (192.168.4.1) (Process ID 1)

  Area 0 has 1  MPLS TE links. Area instance is 3.

  Links in hash bucket 53.
    Link is associated with fragment 0. Link instance is 3
      Link connected to Point-to-Point network
      Link ID :192.168.50.20
      Interface Address :192.168.20.50
      Neighbor Address :192.168.4.1
      Admin Metric :0
      Maximum bandwidth :19440000
      Maximum global pool reservable bandwidth :25000000
      Maximum sub pool reservable bandwidth    :3125000
      Number of Priority :8
      Global pool unreserved BW
      Priority 0 :  25000000  Priority 1 :  25000000
      Priority 2 :  25000000  Priority 3 :  25000000
      Priority 4 :  25000000  Priority 5 :  25000000
      Priority 6 :  25000000  Priority 7 :  25000000
      Sub pool unreserved BW
```

```
Priority 0 :   3125000  Priority 1 :   3125000
Priority 2 :   3125000  Priority 3 :   3125000
Priority 4 :   3125000  Priority 5 :   3125000
Priority 6 :   3125000  Priority 7 :   3125000
Affinity Bit :0
```

Sample Output for the show ospf Command After Configuring MPLS TE

In the following example, the **show route ospf** EXEC command verifies that the MPLS TE tunnels replaced POS interface 0/3/0/0 and that configuration was performed correctly:

```
RP/0/RP0/CPU0:router# show route ospf 1 0

O E2 192.168.10.0/24 [110/20] via 0.0.0.0, 00:00:15, tunnel2
O E2 192.168.11.0/24 [110/20] via 0.0.0.0, 00:00:15, tunnel2
O E2 192.168.1244.0/24 [110/20] via 0.0.0.0, 00:00:15, tunnel2
O    192.168.12.0/24 [110/2] via 0.0.0.0, 00:00:15, tunnel2
```

Verifying OSPF Configuration and Operation

This task explains how to verify the configuration and operation of OSPF.

Note To execute OSPFv3 commands for this task, replace **ospf** with **ospfv3** in Steps 1 through 7.

SUMMARY STEPS

1. **show ospf** [*process-name*]
2. **show ospf** [*process-name*] **border-routers [***router-id***]**
3. **show ospf** [*process-name*] **database**
4. **show ospf** [*process-name*] [*area-id*] **flood-list interface** *type instance*
5. **show ospf** [*process-name*] [*area-id*] **neighbor** [*interface-type interface-instance*] [*neighbor-id*] [**detail**]
6. **clear ospf** [*process-name*] **process**
7. **clear ospf** [*process-name*] **statistics** [**neighbor** [*interface-type interface-instance*] [*ip-address*]]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**show ospf** [*process-name*] **Example:** `RP/0/RP0/CPU0:router# show ospf group1`	(Optional) Displays general information about OSPF routing processes.
Step 2	**show ospf** [*process-name*] **border-routers** [*router-id*] **Example:** `RP/0/RP0/CPU0:router# show ospf group1 border-routers`	(Optional) Displays the internal OSPF routing table entries to an ABR and ASBR.
Step 3	**show ospf** [*process-name*] **database** **Example:** `RP/0/RP0/CPU0:router# show ospf group2 database`	(Optional) Displays the lists of information related to the OSPF database for a specific router. • The various forms of this command deliver information about different OSPF LSAs.
Step 4	**show ospf** [*process-name*] [*area-id*] **flood-list interface** *type instance* **Example:** `RP/0/RP0/CPU0:router# show ospf 100 flood-list interface pos 0/3/0/0`	(Optional) Displays a list of OSPF LSAs waiting to be flooded over an interface.
Step 5	**show ospf** [*process-name*] [*area-id*] **neighbor** [*interface-type interface-instance*] [*neighbor-id*] [**detail**] **Example:** `RP/0/RP0/CPU0:router# show ospf 100 neighbor`	(Optional) Displays OSPF neighbor information on an individual interface basis.
Step 6	**clear ospf** [*process-name*] **process** **Example:** `RP/0/RP0/CPU0:router# clear ospf 100 process`	(Optional) Resets an OSPF router process without stopping and restarting it.
Step 7	**clear ospf** [*process-name*] **statistics** [**neighbor** [*interface-type interface-instance*] [*ip-address*]] **Example:** `RP/0/RP0/CPU0:router# clear ospf 100 statistics`	(Optional) Clears the OSPF statistics of neighbor state transitions.

Configuring OSPFv3 Graceful Restart

This section describes the following tasks for configuring a graceful restart of an OSPFv3 process:

- Enabling Graceful Restart, page RC-221
- Configuring the Maximum Lifetime of a Graceful Restart, page RC-221
- Configuring the Minimum Time Required Between Restarts, page RC-222
- Configuring the Helper Level of the Router, page RC-223
- Displaying Information About Graceful Restart, page RC-224

Enabling Graceful Restart

This section describes how to enable an OSPFv3 graceful restart on the current router. By default, this feature is disabled.

SUMMARY STEPS

1. **configuration**
2. **router ospfv3**
3. **graceful-restart**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**`config`** **Example:** `RP/0/RP0/CPU0:single10-hfr#config` `RP/0/RP0/CPU0:single10-hfr(config)`	Enters global configuration mode.
Step 2	**`router ospfv3`** *`process-name`* **Example:** `RP/0/RP0/CPU0:single10-hfr(config)# router ospfv3 test`	Enters router configuration mode for OSPFv3. The process name is a WORD that uniquely identifies an OSPF routing process. The process name is any alphanumeric string no longer than 40 characters without spaces.
Step 3	**`graceful-restart`** **Example:** `RP/0/RP0/CPU0:single10-hfr(config-ospfv3)#graceful-restart`	Enable graceful restart on the current router.

Configuring the Maximum Lifetime of a Graceful Restart

This section describes the task of modifying the total time that a router can be in graceful restart mode. The default lifetime is 95 seconds. The range is 90–3600 seconds.

SUMMARY STEPS

1. **configuration**
2. **router ospfv3**
3. **graceful-restart lifetime**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**config** **Example:** `RP/0/RP0/CPU0:single10-hfr#config` `RP/0/RP0/CPU0:single10-hfr(config)`	Enters global configuration mode.
Step 2	**router ospfv3** *<process-name>* **Example:** `RP/0/RP0/CPU0:single10-hfr(config)# router ospfv3 test`	Enters router configuration mode for OSPFv3. The process name is a WORD that uniquely identifies an OSPF routing process. The process name is any alphanumeric string no longer than 40 characters without spaces.
Step 3	**graceful-restart lifetime** **Example:** `RP/0/RP0/CPU0:single10-hfr(config-ospfv3)#graceful-restart lifetime 120`	Specifies a maximum duration for a graceful restart.

Configuring the Minimum Time Required Between Restarts

This section describes the task of modifying the minimal time that is required between allowable graceful restarts. The purpose of this interval is to prevent the waste of system resources if the OSPFv3 process is repeatedly crashing for reasons that must be diagnosed. The default value for the interval is 90 seconds. The range is 90–3600 seconds.

SUMMARY STEPS

1. **configuration**
2. **router ospfv3**
3. **graceful-restart interval**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**config** **Example:** `RP/0/RP0/CPU0:single10-hfr#config` `RP/0/RP0/CPU0:single10-hfr(config)`	Enters global configuration mode.
Step 2	**router ospfv3** <*process-name*> **Example:** `RP/0/RP0/CPU0:single10-hfr(config)# router ospfv3 test`	Enters router configuration mode for OSPFv3. The process name is a WORD that uniquely identifies an OSPF routing process. The process name is any alphanumeric string no longer than 40 characters without spaces.
Step 3	**graceful-restart interval** <*seconds*> **Example:** `RP/0/RP0/CPU0:single10-hfr(config-ospfv3)#graceful-restart interval 120`	Specifies the interval (minimal time) between graceful restarts on the current router.

Configuring the Helper Level of the Router

This section describes the task of disabling the helper mode on the current router. By default, a router that is capable of doing an OSPFv3 graceful restart is also enabled to be a helper to a node in graceful mode. The **graceful-restart helper** command lets you disable the current router's helper capability.

SUMMARY STEPS

1. **configuration**
2. **router ospfv3**
3. **graceful-restart helper** [**disable**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**config** **Example:** `RP/0/RP0/CPU0:single10-hfr#config` `RP/0/RP0/CPU0:single10-hfr(config)`	Enters global configuration mode.
Step 2	**router ospfv3** *<process-name>* **Example:** `RP/0/RP0/CPU0:single10-hfr(config)# router ospfv3 test`	Enters router configuration mode for OSPFv3. The process name is a WORD that uniquely identifies an OSPF routing process. The process name is any alphanumeric string no longer than 40 characters without spaces.
Step 3	**graceful-restart helper** **Example:** `RP/0/RP0/CPU0:single10-hfr(config-ospfv3)#graceful-restart helper disable`	Disables the helper capability.

Displaying Information About Graceful Restart

This section describes the tasks you can use to display information about a graceful restart.

- To see if the feature is enabled and when the last graceful restart ran, use the **show ospf** command. To see details for an OSPFv3 instance, use the **show ospf** *process-name* **database grace** command.

Displaying the State of the Graceful Restart Feature

The following screen output shows the state of the graceful restart capability on the local router:

```
RP/0/0/CPU0:LA#show ospfv3 test database grace

 Routing Process “ospfv3 test” with ID 2.2.2.2
 Initial SPF schedule delay 5000 msecs
 Minimum hold time between two consecutive SPFs 10000 msecs
 Maximum wait time between two consecutive SPFs 10000 msecs
 Initial LSA throttle delay 0 msecs
 Minimum hold time for LSA throttle 5000 msecs
 Maximum wait time for LSA throttle 5000 msecs
 Minimum LSA arrival 1000 msecs
 LSA group pacing timer 240 secs
 Interface flood pacing timer 33 msecs
 Retransmission pacing timer 66 msecs
 Maximum number of configured interfaces 255
 Number of external LSA 0. Checksum Sum 00000000
 Number of areas in this router is 1. 1 normal 0 stub 0 nssa
 Graceful Restart enabled, last GR 11:12:26 ago (took 6 secs)
    Area BACKBONE(0)
        Number of interfaces in this area is 1
        SPF algorithm executed 1 times
        Number of LSA 6. Checksum Sum 0x0268a7
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0
RP/0/0/CPU0:LA#
```

Displaying Graceful Restart Information for an OSPFv3 Instance

The following screen output shows the link state for the instance of OSPFv3 called test:

```
RP/0/0/CPU0:LA#show ospfv3 test database grace

            OSPFv3 Router with ID (2.2.2.2) (Process ID test)

            Router Link States (Area 0)
ADV Router      Age         Seq#            Fragment ID  Link count  Bits
1.1.1.1               1949        0x8000000e      0                      1           None
2.2.2.2               2007        0x80000011      0                      1           None

            Link (Type-8) Link States (Area 0)
ADV Router      Age         Seq#              Link ID    Interface
1.1.1.1               180          0x80000006    1           PO0/2/0/0
s2.2.2.2             2007        0x80000006    1           PO0/2/0/0

            Intra Area Prefix Link States (Area 0)
ADV Router      Age         Seq#              Link ID    Ref-lstype  Ref-LSID
1.1.1.1               180         0x80000006    0              0x2001          0
2.2.2.2               2007        0x80000006   0              0x2001          0

            Grace (Type-11) Link States (Area 0)
ADV Router      Age         Seq#                Link ID    Interface
2.2.2.2                2007        0x80000005    1             PO0/2/0/0

RP/0/0/CPU0:LA#
```

Enabling Multicast-Intact for OSPFv2

This optional task describes how to enable multicast-intact for OSPFv2 routes that use IPv4 addresses.

Summary Steps

1. **configure**
2. **router ospf** *instance-id*
3. **mpls traffic-eng multicast-intact**
4. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** RP/0/RP0/CPU0:router# configure	Enters global configuration mode.
Step 2	**router ospf** *instance-id* **Example:** RP/0/RP0/CPU0:router(config)# router ospf isp	Enables OSPF routing for the specified routing process, and places the router in router configuration mode. In this example, the OSPF instance is called isp.

	Command or Action	Purpose
Step 3	**mpls traffic-eng multicast-intact** **Example:** `RP/0/RP0/CPU0:router(config-isis)# mpls traffic-eng multicast-intact`	Enables multicast-intact.
Step 4	**end** or **commit** **Example:** `RP/0/RP0/CPU0:router(config-isis-af)# end` or `RP/0/RP0/CPU0:router(config-isis-af)# commit`	Saves configuration changes. • When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` – Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. – Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. – Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring the Multi-VRF Capability for OSPF Routing

This task explains how to configure multi-VRF capability for OSPF Routing. This task is implemented for OSPFv2 only.

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
3. **vrf** *vrf-name*
4. **domain-id** [**secondary**] **type** {**0005** | **0105** | **0205** | **8005**} **value** *value*
5. **domain-tag** *tag*
6. **disable-dn-bit-check**
7. **interface** *type instance*
8. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**router ospf** *process-name* **Example:** `RP/0/RP0/CPU0:router(config)# router ospf 1`	Enables OSPF routing for the specified routing process and places the router in router configuration mode. **Note** The *process-name* argument is any alphanumeric string no longer than 40 characters.
Step 3	**vrf** *vrf-name* **Example:** `RP/0/RP0/CPU0:router(config-ospf)# vrf vrf1`	Creates a VPN routing anf forwarding (VRF) instance and enters VRF configuration mode.
Step 4	**domain-id** [**secondary**] **type** {**0005** | **0105** | **0205** | **8005**} **value** *value* **Example:** `RP/0/RP0/CPU0:router(config-ospf-vrf)# domain-id 0105 1AF234`	Specifies the OSPF VRF domain ID. • The *value* argument is a six-octet hex number.
Step 5	**domain-tag** *tag* **Example:** `RP/0/RP0/CPU0:router(config-0spf-vrf)# domain-tag 234`	Specifies the OSPF VRF domain tag. • The valid range for *tag* is 0 to 4294967295.

	Command or Action	Purpose
Step 6	**`disable-dn-bit-check`** **Example:** `RP/0/RP0/CPU0:router(config-ospf-vrf)# disable-dn-bit-check`	Specifies that down bits should be ignored.
Step 7	**`interface`** *`type instance`* **Example:** `RP/0/RP0/CPU0:router(config-ospf-vrf)# interface interface loopback0`	Enters interface configuration mode and associates one or more interfaces to the VRF.
Step 8	**`end`** or **`commit`** **Example:** `RP/0/RP0/CPU0:router(config-if)# end` or `RP/0/RP0/CPU0:router(config-if)# commit`	Saves configuration changes. • When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` – Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. – Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. – Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Associating Interfaces to a VRF

This task explains how to associate an interface with a VPN Routing and Forwarding (VRF) instance.

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
3. **vrf** *vrf-name*
4. **interface** *type instance*
5. **ipv4 address** *ip-address mask*
6. **ipv6 address** *ipv6-prefix/prefix-length* [**eui-64**]
7. **ipv4 mtu** *mtu*

8. **end**
or
commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**router ospf** *process-name* **Example:** `RP/0/RP0/CPU0:router(config)# router ospf 1`	Enables OSPF routing for the specified routing process and places the router in router configuration mode. **Note** The *process-name* argument is any alphanumeric string no longer than 40 characters.
Step 3	**vrf** *vrf-name* **Example:** `RP/0/RP0/CPU0:router(config-ospf)# vrf vrf1`	Creates a VRF instance and enters VRF configuration mode.
Step 4	**interface** *type instance* **Example:** `RP/0/RP0/CPU0:router(config-ospf-vrf)# interface POS 0/0/0/0`	Enters interface configuration mode and associates one or more interfaces to the VRF.
Step 5	**ipv4 address** *ip-address mask* **Example:** `RP/0/RP0/CPU0:router(config-if)# ipv4 address 172.18.189.38 255.255.255.224`	Assigns an IP address and subnet mask to the interface.
Step 6	**ipv6 address** *ipv6-prefix/prefix-length* [**eui-64**] **Example:** `RP/0/RP0/CPU0:router(config-if)# ipv6 address 2001:0DB8:C18:1::64`	Specifies the IPv6 address assigned to the interface and enables IPV6 processing on the interface. • A slash-mark (/) must preceed the *prefix-length* argument, and there is no space between the *ipv6-prefix* argument and the slash.

	Command or Action	Purpose
Step 7	**ipv4 mtu** *mtu* **Example:** `RP/0/RP0/CPU0:router(config-if)# ipv4 mtu 300`	Sets the maximum transmission unit (MTU) size of IPv4 packets sent on the interface.
Step 8	**end** or **commit** **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar-if)# end` or `RP/0/RP0/CPU0:router(config-ospf-ar-if)# commit`	Saves configuration changes. • When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` – Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. – Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. – Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring OSPF as a Provider Edge to Customer Edge (PE-CE) Protocol

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
3. **vrf** *vrf-name*
4. **router-id** {*router-id* | *interface-type interface-instance*}
5. **redistribute** *protocol* [*process-id*] {**level-1** | **level-1-2** | **level-2**} [**metric** *metric-value*] [**metric-type** *type-value*] [**match** {**internal** | **external** [{**1** | **2**}] | **nssa-external** {**1** | **2**}] [**tag** *tag-value*] [**route-map** *map-tag* | **route-policy** *policy-tag*]
6. **area** *area-id*
7. **interface** *type instance*
8. **exit**
9. **domain-id** [**secondary**] **type** {**0005** | **0105** | **0205** | **8005**} **value** *value*
10. **domain-tag** *tag*

11. **disable-dn-bit-check**
12. **end**
    or
    commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**`configure`** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**`router ospf`** *`process-name`* **Example:** `RP/0/RP0/CPU0:router(config)# router ospf 1`	Enables OSPF routing for the specified routing process and places the router in router configuration mode. **Note** The *process-name* argument is any alphanumeric string no longer than 40 characters.
Step 3	**`vrf`** *`vrf-name`* **Example:** `RP/0/RP0/CPU0:router(config-ospf)# vrf vrf1`	Creates a VRF instance and enters VRF configuration mode.
Step 4	**`router-id`** {*`router-id`* | *`interface-type interface-instance`*} **Example:** `RP/0/RP0/CPU0:router(config-ospf-vrf)# router-id 192.168.4.3`	Configures a router ID for the OSPF process. **Note** We recommend using a stable IPv4 address as the router ID.
Step 5	**`redistribute`** *`protocol`* [*`process-id`*] {**`level-1`** | **`level-1-2`** | **`level-2`**} [**`metric`** *`metric-value`*] [**`metric-type`** *`type-value`*] [**`match`** {**`internal`** | **`external`** [{**`1`** | **`2`**} | **`nssa-external`** {**`1`** | **`2`**}] [**`tag`** *`tag-value`*] [**`route-map`** *`map-tag`* | **`route-policy`** *`policy-tag`*] **Example:** `RP/0/RP0/CPU0:router(config-ospf-vrf)# redistribute bgp 1 level-1`	Redistributes OSPF routes from one routing domain to another routing domain. • This command causes the router to become an ASBR by definition. • OSPF tags all routes learned through redistribution as external. • The protocol and its process ID, if it has one, indicate the protocol being redistributed into OSPF. • The metric is the cost you assign to the external route. The default is 20 for all protocols except BGP, whose default metric is 1. • The example shows the redistribution of BGP autonomous system 1, Level 1 routes into OSPF as Type 2 external routes.

	Command or Action	Purpose
Step 6	**area** *area-id* **Example:** `RP/0/RP0/CPU0:router(config-ospf-vrf)# area 0`	Enters area configuration mode and configures an area for the OSPF process. • The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area.
Step 7	**interface** *type instance* **Example:** `RP/0/RP0/CPU0:router(config-ospf-vrf)# interface POS 0/0/0/0`	Enters interface configuration mode and associates one or more interfaces to the VRF.
Step 8	**exit** **Example:** `RP/0/RP0/CPU0:router(config-if)# exit`	Exits interface configuration mode.
Step 9	**domain-id** [**secondary**] **type** {**0005** | **0105** | **0205** | **8005**} **value** *value* **Example:** `RP/0/RP0/CPU0:router(config-ospf-vrf)# domain-id 0105 1AF234`	Specifies the OSPF VRF domain ID. • The *value* argument is a six-octet hex number.
Step 10	**domain-tag** *tag* **Example:** `RP/0/RP0/CPU0:router(config-0spf-vrf)# domain-tag 234`	Specifies the OSPF VRF domain tag. • The valid range for *tag* is 0 to 4294967295.

	Command or Action	Purpose
Step 11	**disable-dn-bit-check** **Example:** `RP/0/RP0/CPU0:router(config-ospf-vrf)# disable-dn-bit-check`	Specifies that down bits should be ignored.
Step 12	**end** or **commit** **Example:** `RP/0/RP0/CPU0:router(config-ospf-vrf)# end` or `RP/0/RP0/CPU0:router(config-ospf-vrf)# commit`	Saves configuration changes. • When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` – Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. – Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. – Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring LDP-IGP Synchronization

This task explains how to synchronize Label Distribution Protocol (LDP) with Interior Gateway Protocol (IGP) on an OSPF interface.

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
3. **area** *area-id*
4. **interface** *type instance*
5. **mpls ldp sync**
6. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**router ospf** *process-name* **Example:** `RP/0/RP0/CPU0:router(config)# router ospf 1`	Enables OSPF routing for the specified routing process and places the router in router configuration mode. **Note** The *process-name* argument is any alphanumeric string no longer than 40 characters.
Step 3	**area** *area-id* **Example:** `RP/0/RP0/CPU0:router(config-ospf)# area 0`	Enters area configuration mode and configures an area for the OSPF process. • The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area.
Step 4	**interface** *type instance* **Example:** `RP/0/RP0/CPU0:router(config-ospf-vrf)# interface POS 0/0/0/0`	Enters interface configuration mode and associates one or more interfaces to the VRF.
Step 5	**mpls ldp sync** **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# mpls ldp sync`	Enables Label Distribution Protocol (LDP)-Interior Gateway Protocol (IGP) synchronization.
Step 6	**end** or **commit** **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar-if)# end` or `RP/0/RP0/CPU0:router(config-ospf-ar-if)# commit`	Saves configuration changes. • When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` – Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. – Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. – Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Creating Multiple OSPF Instances (OSPF Process and a VRF)

This task explains how to create multiple OSPF instances. In this case, the instances are a normal OSPF instance and a VRF instance.

SUMMARY STEPS

1. **configure**
2. **router ospf** *process-name*
3. **area** *area-id*
4. **interface** *type instance*
5. **exit**
6. **vrf** *vrf-name*
7. **area** *area-id*
8. **interface** *type instance*
9. **end**
   or
   commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**router ospf** *process-name* **Example:** `RP/0/RP0/CPU0:router(config)# router ospf 1`	Enables OSPF routing for the specified routing process and places the router in router configuration mode. **Note** The *process-name* argument is any alphanumeric string no longer than 40 characters.
Step 3	**area** *area-id* **Example:** `RP/0/RP0/CPU0:router(config-ospf)#  area 0`	Enters area configuration mode and configures a backbone area. • The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area. We recommend using the IPv4 address notation.
Step 4	**interface** *type instance* **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# interface POS 0/1/0/3`	Enters interface configuration mode and associates one or more interfaces to the area.

	Command or Action	Purpose
Step 5	**exit** **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar)# exit`	Enters OSPF configuration mode.
Step 6	**vrf** *vrf-name* **Example:** `RP/0/RP0/CPU0:router(config-ospf)# vrf vrf1`	Creates a VRF instance and enters VRF configuration mode.
Step 7	**area** *area-id* **Example:** `RP/0/RP0/CPU0:router(config-ospf-vrf)# area 0`	Enters area configuration mode and configures an area for a VRF instance under the OSPF process. • The *area-id* argument can be entered in dotted-decimal or IPv4 address notation, such as area 1000 or area 0.0.3.232. However, you must choose one form or the other for an area.
Step 8	**interface** *type instance* **Example:** `RP/0/RP0/CPU0:router(config-ospf-vrf)# interface POS 0/0/0/0`	Enters interface configuration mode and associates one or more interfaces to the VRF.
Step 9	**end** or **commit** **Example:** `RP/0/RP0/CPU0:router(config-ospf-ar-if)# end` or `RP/0/RP0/CPU0:router(config-ospf-ar-if)# commit`	Saves configuration changes. • When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` – Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. – Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. – Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuration Examples for Implementing OSPF on Cisco IOS XR Software

This section provides the following configuration examples:

- Cisco IOS XR for OSPF Version 2 Configuration: Example, page RC-237

Cisco IOS XR for OSPF Version 2 Configuration: Example

The following example shows how an OSPF interface is configured for an area in Cisco IOS XR software.

In Cisco IOS XR software, area 0 must be explicitly configured with the **area** command and all interfaces that are in the range from 10.1.2.0 to 10.1.2.255 are bound to area 0. Interfaces are configured with the **interface** command (while the router is in area configuration mode) and the **area** keyword is not included in the interface statement.

Cisco IOS XR Software Configuration

```
interface POS 0/3/0/0
 ip address 10.1.2.1 255.255.255.255
 negotiation auto
!
router ospf 1
router-id 10.2.3.4
 area 0
  interface POS 0/3/0/0
!
!
```

The following example shows how OSPF interface parameters are configured for an area in Cisco IOS XR software.

In Cisco IOS XR software, OSPF interface-specific parameters are configured in interface configuration mode and explicitly defined for area 0. In addition, the **ip ospf** keywords are no longer required.

Cisco IOS XR Software Configuration

```
interface POS 0/3/0/0
 ip address 10.1.2.1 255.255.255.0
 negotiation auto
!
router ospf 1
 router-id 10.2.3.4
 area 0
  interface POS 0/3/0/0
   cost 77
   mtu-ignore
   authentication message-digest
   message-digest-key 1 md5 0 test
!
!
```

The following example shows the hierarchical CLI structure of Cisco IOS XR software.

In Cisco IOS XR software, OSPF areas must be explicitly configured, and interfaces configured under the area configuration mode are explicitly bound to that area. In this example, interface 10.1.2.0/24 is bound to area 0 and interface 10.1.3.0/24 is bound to area 1.

Cisco IOS XR Software Configuration

```
interface POS 0/3/0/0
 ip address 10.1.2.1 255.255.255.0
 negotiation auto
!
interface POS 0/3/0/1
 ip address 10.1.3.1 255.255.255.0
 negotiation auto
!
router ospf 1
 router-id 10.2.3.4
 area 0
  interface POS 0/3/0/0
!
 area 1
  interface POS 0/3/0/1
!
!
```

CLI Inheritance and Precedence for OSPF Version 2: Example

The following example configures the cost parameter at different hierarchical levels of the OSPF topology, and illustrates how the parameter is inherited and how only one setting takes precedence. According to the precedence rule, the most explicit configuration is used.

The cost parameter is set to 5 in router configuration mode for the OSPF process. Area 1 sets the cost to 15 and area 6 sets the cost to 30. All interfaces in area 0 inherit a cost of 5 from the OSPF process because the cost was not set in area 0 or its interfaces.

In area 1, every interface has a cost of 15 because the cost is set in area 1 and 15 overrides the value 5 that was set in router configuration mode.

Area 4 does not set the cost, but POS interface 01/0/2 sets the cost to 20. The remaining interfaces in area 4 have a cost of 5 that is inherited from the OSPF process.

Area 6 sets the cost to 30, which is inherited by POS interfaces 0/1/0/3 and 0/2/0/3. POS interface 0/3/0/3 uses the cost of 1, which is set in interface configuration mode.

```
router ospf 1
 router-id 10.5.4.3
 cost 5
 area 0
  interface POS 0/1/0/0
  !
  interface POS 0/2/0/0
  !
  interface POS 0/3/0/0
  !
 !
 area 1
  cost 15
  interface POS 0/1/0/1
  !
  interface POS 0/2/0/1
  !
  interface POS 0/3/0/1
```

```
  !
 !
 area 4
  interface POS 0/1/0/2
   cost 20
  !
  interface POS 0/2/0/2
  !
  interface POS 0/3/0/2
  !
 !
 area 6
  cost 30
  interface POS 0/1/0/3
  !
  interface POS 0/2/0/3
  !
  interface POS 0/3/0/3
   cost 1
  !
 !
```

MPLS TE for OSPF Version 2: Example

The following example shows how to configure the OSPF portion of MPLS TE. However, you still need to build an MPLS TE topology and create an MPLS TE tunnel. See the *Cisco IOS XR MPLS Configuration Guide* for information.

In this example, loopback interface 0 is associated with area 0 and area 0 is declared to be an MPLS area:

```
interface Loopback 0
 ip address 10.10.10.10 255.255.255.0
!
interface POS 0/2/0/0
 ip address 10.1.2.2 255.255.255.0
!
router ospf 1
 router-id 10.10.10.10
 nsf
 auto-cost reference-bandwidth 10000
 area 0
  interface POS 0/2/0/0
  interface Loopback 0
 mpls traffic-eng area 0
 mpls traffic-eng router-id Loopback 0
```

ABR with Summarization for OSPFv3: Example

The following example shows the prefix range 2300::/16 summarized from area 1 into the backbone:

```
router ospfv3 1
 router-id 192.168.0.217
 area 0
  interface POS 0/2/0/1
 area 1
  range 2300::/16
  interface POS 0/2/0/0
```

ABR Stub Area for OSPFv3: Example

The following example shows that area 1 is configured as a stub area:

```
router ospfv3 1
 router-id 10.0.0.217
 area 0
  interface POS 0/2/0/1
 area 1
  stub
  interface POS 0/2/0/0
```

ABR Totally Stub Area for OSPFv3: Example

The following example shows that area 1 is configured as a totally stub area:

```
router ospfv3 1
 router-id 10.0.0.217
 area 0
  interface POS 0/2/0/1
 area 1
  stub no-summary
  interface POS 0/2/0/0
```

Route Redistribution for OSPFv3: Example

The following example uses prefix lists to limit the routes redistributed from other protocols.

Only routes with 9898:1000 in the upper 32 bits and with prefix lengths from 32 to 64 are redistributed from BGP 42. Only routes *not* matching this pattern are redistributed from BGP 1956.

```
ipv6 prefix-list list1
 seq 10 permit 9898:1000::/32 ge 32 le 64

ipv6 prefix-list list2
 seq 10 deny 9898:1000::/32 ge 32 le 64
 seq 20 permit ::/0 le 128

router ospfv3 1
 router-id 10.0.0.217
 redistribute bgp 42
 redistribute bgp 1956
 distribute-list prefix-list list1 out bgp 42
 distribute-list prefix-list list2 out bgp 1956
 area 1
  interface POS 0/2/0/0
```

Virtual Link Configured Through Area 1 for OSPFv3: Example

This example shows how to set up a virtual link to connect the backbone through area 1 for the OSPFv3 topology that consists of areas 0 and 1 and virtual links 10.0.0.217 and 10.0.0.212:

ABR 1 Configuration

```
router ospfv3 1
 router-id 10.0.0.217
 area 0
```

```
  interface POS 0/2/0/1
 area 1
  virtual-link 10.0.0.212
  interface POS 0/2/0/0
```

ABR 2 Configuration

```
router ospfv3 1
 router-id 10.0.0.212
 area 0
  interface POS 0/3/0/1
 area 1
  virtual-link 10.0.0.217
  interface POS 0/2/0/0
```

Virtual Link Configured with MD5 Authentication for OSPF Version 2: Example

The following examples show how to configure a virtual link to your backbone and apply MD5 authentication. You must perform the steps described on both ABRs at each end of the virtual link.

After you explicitly configure the ABRs, the configuration is inherited by all interfaces bound to that area—unless you override the values and configure them explicitly for the interface.

To understand virtual links, see the "Virtual Link and Transit Area for OSPF" section on page 180.

In this example, all interfaces on router ABR1 use MD5 authentication:

```
router ospf ABR1
  router-id 10.10.10.10
  authentication message-digest
  message-digest-key 100 md5 0 cisco
  area 0
    interface pos 0/2/0/1
    interface pos 0/3/0/0
  area 1
    interface pos 0/3/0/1
    virtual-link 10.10.5.5
  !
!
```

In this example, only area 1 interfaces on router ABR3 use MD5 authentication:

```
router ospf ABR2
  router-id 10.10.5.5
  area 0
  area 1
    authentication message-digest
    message-digest-key 100 md5 0 cisco
    interface pos 0/9/0/1
    virtual-link 10.10.10.10
  area 3
    interface Loopback 0
    interface pos 0/9/0/0
  !
!
```

Where to Go Next

To configure route maps through the RPL for OSPF Version 2, see the *Implementing Routing Policy on Cisco IOS XR Software* document.

To build an MPLS TE topology, create tunnels, and configure forwarding over the tunnel for OSPF Version 2; see the *Cisco IOS XR MPLS Configuration Guide*.

Additional References

The following sections provide references related to implementing OSPF on Cisco IOS XR software.

Related Documents

Related Topic	Document Title
OSPF and OSPFv3 commands: complete command syntax, command modes, command history, defaults, usage guidelines, and examples	*Cisco IOS XR Routing Command Reference*, Release 3.3
MPLS TE feature information	*Implementing MPLS Traffic Engineering on Cisco IOS XR Software* module in the *Cisco IOS XR MPLS Configuration Guide*, Release 3.2

Standards

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

MIBs	MIBs Link
• OSPF-MIB	To locate and download MIBs for selected platforms using Cisco IOS XR software, use the Cisco MIB Locator found at the following URL: http://cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml

RFCs

RFCs	Title
RFC 1587	*Not so Stubby Area (NSSA)*
RFC 1793	*OSPF over demand circuit*
RFC 2328	*OSPF Version 2*
RFC 2740	*OSPFv3*
RFC 3623	*Graceful OSPF Restart (OSPFv2)*

Technical Assistance

Description	Link
The Cisco Technical Support website contains thousands of pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.	http://www.cisco.com/techsupport